PROMETHEE

METHODS

ULB

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Solvay Brussels School
Economics & Management

MultiCriteria Decision Aid with **PROMETHEE & GAIA**

*How to make **better** and more **sustainable decisions***

Πανεπιστήμιο Μακεδονίας
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Course Schedule

- *Tuesday 4* – **What? Why? How?**
  - What is multicriteria decision aid.
  - Why you should use multicriteria decision aid.
  - **PROMETHEE & GAIA**
- *Wednesday 5* – **The software**
  - Advanced features.
  - Using **PROMETHEE** and the **Visual PROMETHEE** software.
  - Hands-on training.
- *Thursday 6* – **Practice**
  - Exercises.
  - Case studies (homeworks).

Tuesday 4

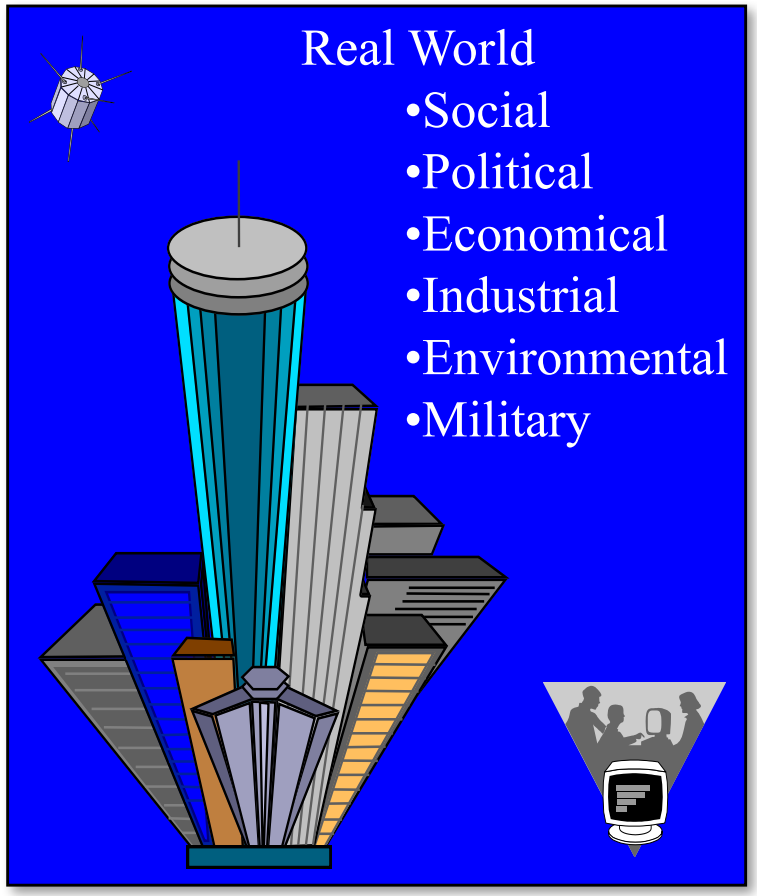
What? Why? How?

- What is multicriteria decision aid:
  - Optimization vs multicriteria decision aid.
  - Sustainable decisions.
  - Models and main approaches.
- Why you should use multicriteria decision aid.
- **PROMETHEE & GAIA.**

Decisions

- Personal decisions
  - Choose a restaurant tonight
  - Choose a university
  - Purchase a new phone, a new car, …
- Business decisions
  - Develop a new product
  - Choose a computer system
  - Investments, strategies, project management, …
- Political decisions
  - Join the EU… Leave the EU…
  - Build a new hospital
  - Regional investment, taxes, …

Decision Making

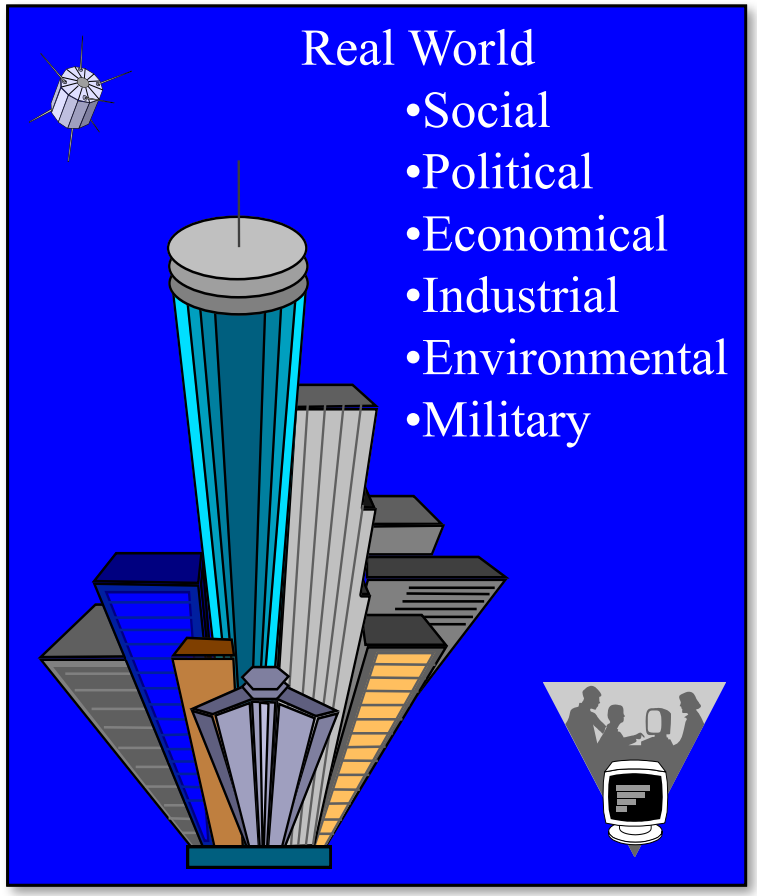


- Describe,
- Understand,
- Manage.

2 Approaches :

- Qualitative approach,
- Quantitative approach.

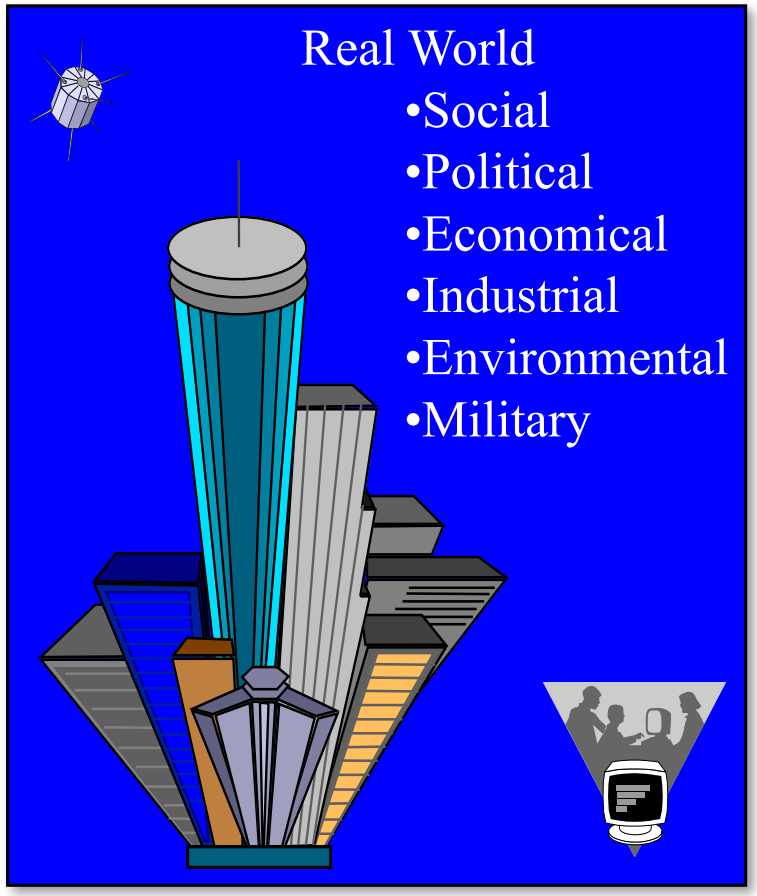
Decision Aid



Quantitative model

- Possible decisions?
- How to compare them?
- Preferences, Objectives?

Decision Aid



Quantitative model

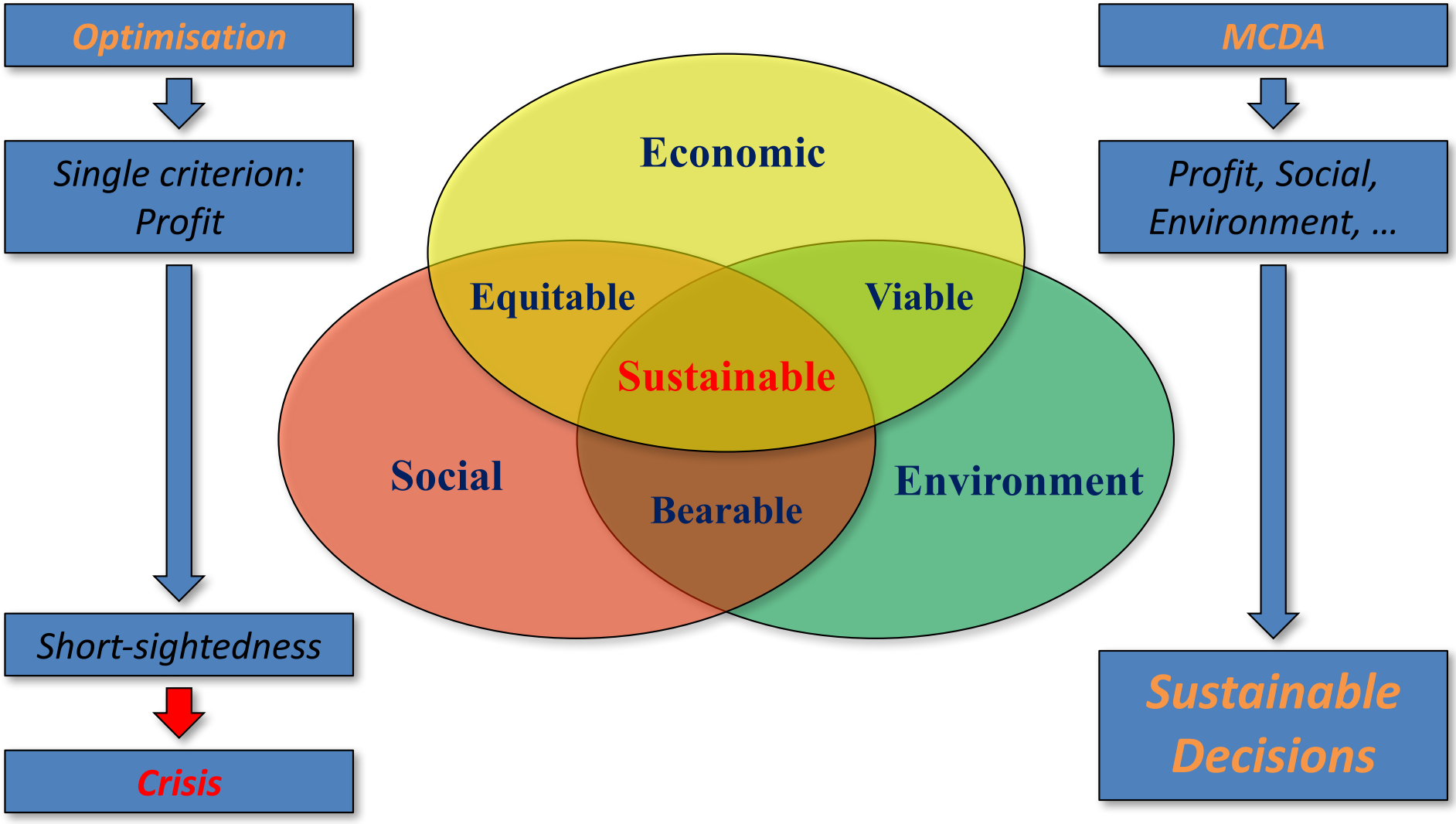
- Approximation to real world!

➢ Decision Aid.

Quantitative Model?

- Describe possible decisions (actions)?
  - List, variables, …
- Objective? Best decision? Best choice?
  - Minimize costs?
  - Maximize profit?
  - Maximize quality?
  - Minimize impacts?
- Optimization models?
- Or MCDA (MultiCriteria Decision Aid) models…

MCDA vs Optimisation



Some Decision or Evaluation Problems

- Locating a new plant, a new shop, ...
- Human resources management.
- Purchasing equipment.
- Assessing the quality of suppliers.
- Evaluating projects.
- Selecting an investment strategy.
- Making political decisions…

What? Why? How?

- What are we facing?
  - Decision problems involving multiple and conflicting issues.
  - Decision problems involving the future of Mankind.
- Why should we care?
  - Robin Hood is dead.
  - Short-term profit is ruling.

- How can we face it?
  - Think ethical.
  - Share. React. Act.
  - Need for models to avoid subjectivity and unethical behavior.

Which models?

- Qualitative models?
  - Subjective!
- Unicriterion models?
  - Less subjective,
  - Short-sighted!
- Multicriteria models?
  - More open,
  - Still models…

Unicriterion vs Multicriteria Model

- **Unicriterion model:**

$$\text{Optimise}\{g(a) | a \in A\}$$

  - Mathematically well-stated:
    - Optimal solution,
    - Complete ranking of the actions.
  - Socio-economically ill-stated:
    - Single criterion? Not realistic.
    - Notion of criterion: perception thresholds, …

Unicriterion vs Multicriteria Model

- **Multicriteria model:**

$$\text{Optimise}\{g_1(a), g_2(a), \ldots, g_k(a) \mid a \in A\}$$

  - Mathematically ill-stated:
    - No optimal solution,
    - No mathematical meaning.
  - Socio-economically well-stated:
    - Closer to real world decision problem,
    - Search for a compromise solution.

Multicriteria Table

- Actions:
  - Possible decisions,
  - items to evaluate.
- Criteria:
  - quantitative,
  - qualitative.

Multicriteria Table

	Crit. 1 (/20)	Crit. 2 (rating)	Crit. 3 (qual.)	Crit. 4 (Y/N)	…
Action 1	18	135	G	Yes	…
Action 2	9	147	B	Yes	…
Action 3	15	129	VG	No	…
Action 4	12	146	VB	?	…
Action 5	7	121	G	Yes	…
…	…	…	…	…	…

Plant Location

	Investment (M€)	Costs (k€)	Environm. (impact)	…
Site 1	18	135	G	…
Site 2	9	147	B	…
Site 3	15	129	VG	…
Site 4	12	146	VB	…
Site 5	7	121	G	…
…	…	…	…	…

Purchase Options

	Price (€)	Reliability (days)	Maintenance (estimate)	…
Product A	18	135	G	…
Product B	9	147	B	…
Product C	15	129	VG	…
Product D	12	146	VB	…
Product E	7	121	G	…
…	…	…	…	…

A Simple Example

The purchase of a new car by a Greek family

Objectives:

- Economy (price),
- Usage (fuel consumption),
- Performance (power),
- Space,
- Comfort.

Multicriteria Table

Cars	Price	Power	Fuel	Space	Comfort
Tourism A	26.000 €	75	8,0	average	average
Sport	29.000 €	110	9,0	very bad	bad
Tourism B	25.500 €	85	7,0	good	average
Luxury 1	38.000 €	90	8,5	good	very good
Economic	15.000 €	50	7,5	bad	very bad
Luxury 2	35.000 €	85	9,0	very good	good

- Best buy?
- Best compromise?
- Priorities of the buyer?

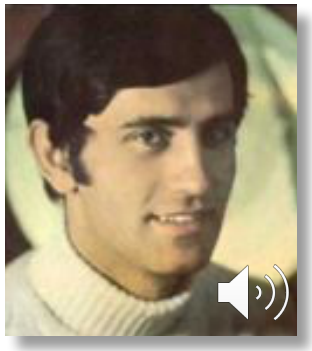
Who is the decision maker?

Dad (Ιάσων)?

He would prefer to save money for holidays in sunny Belgium but needs space for mom's suitcases…

Mom (Ελευθερία)?

She would prefer a red one…



The kid (Γιώργος)?

He doesn't care too much about money… More about speed and ρεμπέτικο τραγούδι!

One or Several Stakeholders ?

- Single stakeholder:
  - One actor (the decision maker).
  - One multicriteria table and one preference structure.
- Multiple stakeholders:
  - Several actors (including decision maker(s)).
  - Several multicriteria tables and preference structures.
  - Search for consensus.

Example

- A Greek family.
- Three stakeholders (“decision makers”):
  - Ιάσων (dad),
  - *Ελευθερία* (mom),
  - Γιώργος (the kid).
- Three scenarios.
- Three multicriteria tables:
  - Different priorities.
  - Subjective evaluation of comfort.

Homework Assignment

- For Thursday.
- By small groups of 4 to 6 students.
- Set up a multicriteria decision problem:
  - Actual or fictive.
  - Including minimum 6 actions, 5 criteria and 2 scenarios.
  - Prepare the multicriteria evaluation table.
  - Think about preference functions and criteria weights.

How to?

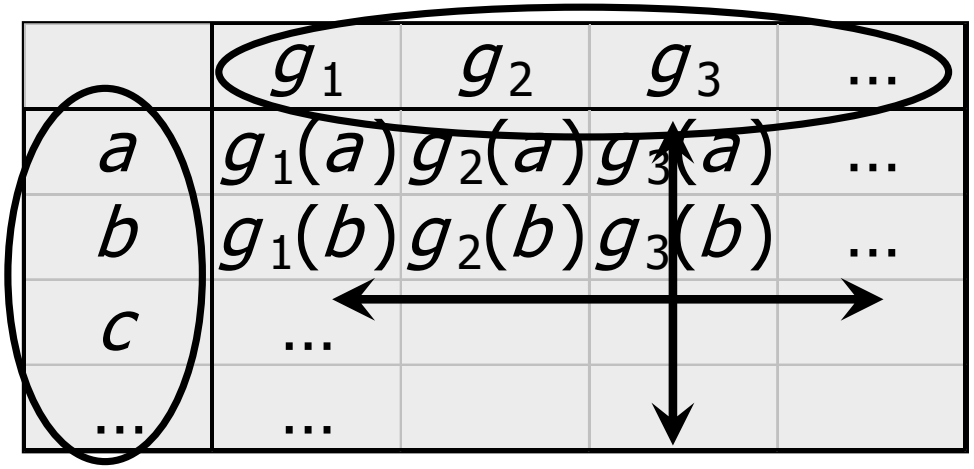
- What is the problem?
- What are the issues?
- Who is involved (stakeholders)?
- What is possible (decisions)?
- What is at stake (objectives)?
- How to measure achievement (criteria)?

➢ **Modeling…**

Modeling… 1… 2… 3…

2.
Define the
criteria

1.
Define the
actions



3.
Model
preferences

1. Defining the actions

- Challenge:
  - Be exhaustive.
  - Open the options.
- Definition: Let A the set of actions. A can be defined:
  - **in extension**:
    by enumeration of its elements.
    ➔ relatively small number of actions.
  - **in comprehension**:
    by constraints on a set of decision variables.
    (Cf. linear programming)
    ➔ large number or infinity of actions.

Some properties of the set of actions

The set of actions A can be:

- **stable**: a priori defined, doesn't evolve.

  or

- **evolutive**: can evolve during the procedure.

- **globalized**: mutually exclusive elements.

  or

- **fragmented**: combinations of actions are considered.

2. Defining the criteria

- Definition:
  function g defined on A, taking its values in a totally ordered set, and representing an objective of the decision-maker(s).
- Challenge:

  Consistent family of criteria:

  – Include all aspects of the decision problem, all the objectives of the decision-maker(s),
  – Avoid redundancies.

Qualitative vs Quantitative Criteria

- Quantitative criteria:
  - Natural numerical scale.
- Qualitative criteria:
  - Qualitative ordinal scale (ex: Likert scales).
  - Maximum 9 levels (7 ± 2) to ensure a consistent evaluation.
  - Presence of a neutral level?
  - Examples:
    - Very good, Good, Average, Bad, Very bad
    - Yes, No
    - ++, +, 0, -, --
    - ++, +, -, --
  - Underlying numerical scale (coding).

3. Modeling preferences

- Problem:

  How to compare two actions a and b to each other?

- A first model: 3 possible results:
  1. Preference: aPb or bPa
  2. Indifference: aIb
  3. Incomparability: aRb

Traditional preference structure (unicriterion)

- Optimisation of a function g on A

$$\forall a,b \in A: \begin{cases} aPb & \Leftrightarrow & g(a) > g(b) \\ aIb & \Leftrightarrow & g(a) = g(b) \end{cases}$$

- Consequences:

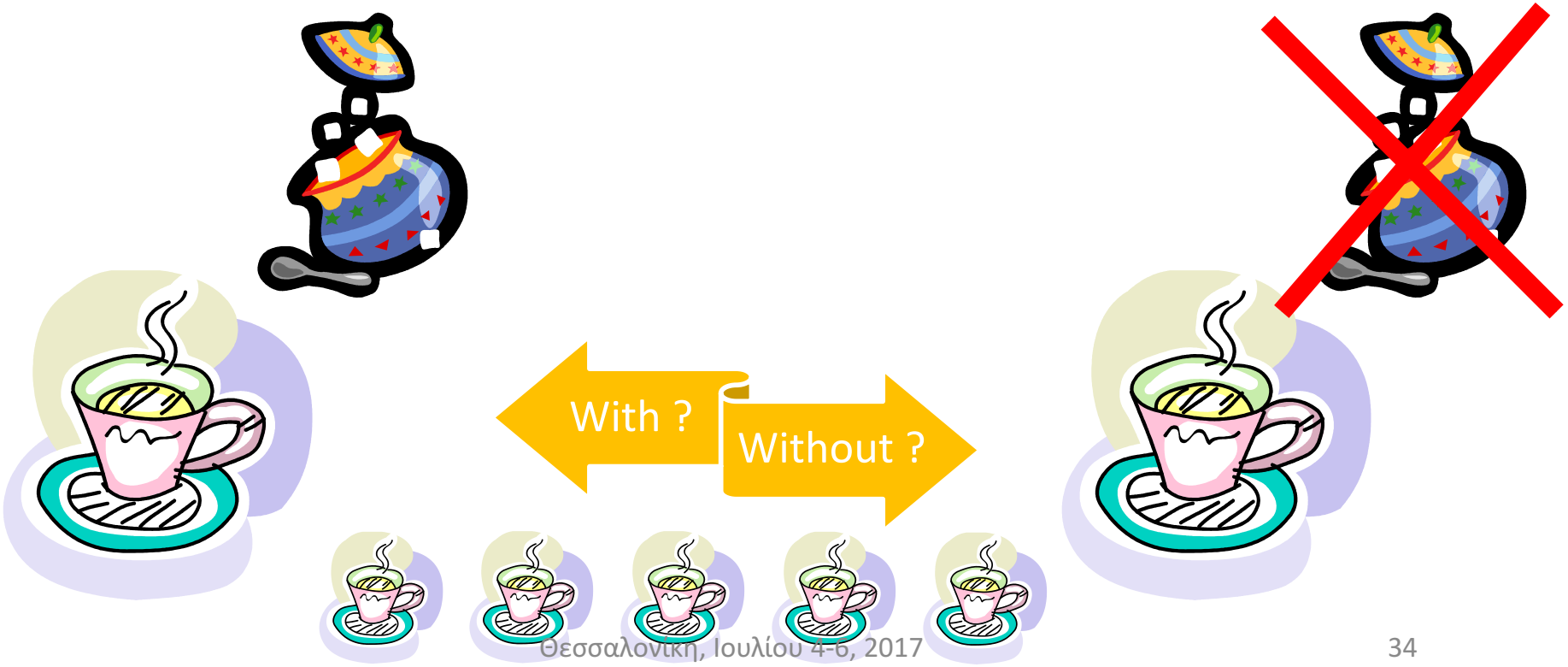
R is empty
P is transitive
I is transitive

- Complete ranking.

The notion of indifference threshold

- Problem: Indifference can be intransitive.

  Cf. Coffee cup paradox (Luce, 1956)



The notion of indifference threshold

- Problem: Indifference can be intransitive.

  Cf. Coffee cup paradox (Luce, 1956)

- Introduction of an indifference threshold:

$$\forall a,b \in A: \begin{cases} aPb & \Leftrightarrow \quad g(a) > g(b) + q \\ aIb & \Leftrightarrow \quad \left| g(a) - g(b) \right| \leq q \end{cases}$$

- Quasi-order : P is transitive, but not I.

Other preference structures

- Variable indifference threshold
  $\Rightarrow$ Interval order.
- Preference + indifference thresholds
  $\Rightarrow$ Pseudo-order.
- Models including incomparability
  $\Rightarrow$ Partial orders.
- Valued preference structures.

Used by PROMETHEE

Different Problematics

	g_1	g_2	g_3	…
a	$g_1(a)$	$g_2(a)$	$g_3(a)$	…
b	$g_1(b)$	$g_2(b)$	$g_3(b)$	…
c	…			
…	…			

Evaluations

- n actions
- k criteria

- α - **choice**: determine a subset of actions (the « best ones »).
- β - **sorting**: sort actions in predefined categories.
- γ - **ranking**: rank from the best to the worst action.
- δ - **description**: describe actions and their consequences.

Unicriterion Model: Optimization

- Optimal solution
  - Maximum or minimum of criterion value.
  - Mathematically well-defined.
  - Generally exists.
- Optimization algorithms
  - Adapted to specific cases (linear programming, branch and bound, network optimization, …).
  - ”Proved”.

Multicriteria Model: Dominance and efficiency

- « Objective ».
- Based on a unanimity principle:

$$a \text{ dominates } b \Leftrightarrow g_h(a) \geq g_h(b) \ \forall \ h$$

- Efficiency: a is efficient if it is not dominated by any other action.
- Problems:
  - Dominance is poor (few dominances),
  - Many actions are efficient.

Multicriteria Table

Cars	Price	Power	Fuel	Space	Comfort
Tourism A	26.000 €	75	8,0	average	average
Sport	29.000 €	110	9,0	very bad	bad
Tourism B	25.500 €	85	7,0	good	average
Luxury 1	38.000 €	90	8,5	good	very good
Economic	15.000 €	50	7,5	bad	very bad
Luxury 2	35.000 €	85	9,0	very good	good

- Best buy?
- Best compromise?
- Priorities of the buyer?

Objections to Dominance

I	g_1	g_2
a	100	100
b	20	30

- a efficient
- a preferred to b

II	g_1	g_2
a	100	30
b	20	100

- a and b efficient
- a and b incomp.

III	g_1	g_2
a	100	99
b	20	100

- a and b efficient
- a preferred to b

IV	g_1	g_2
a	100	99
b	99	100

- a and b efficient
- a and b indifferent

V	g_1	g_2
a	100	100
b	99	99

- a efficient
- a and b indifferent

Some Characteristics
for a good multicriteria method

- Take into account **deviations** between evaluations.
- Take **scale** effects into account.
- Build either a **partial** (P,I,R) or a **complete** (P,I) ranking of the actions.
- Stay sufficiently **simple**:
  - **no** black box,
  - **no** technical parameters.

A common approach:
The weighted sum

Criteria

Actions or Decisions

	g_1	g_2	g_3	...
a	$g_1(a)$	$g_2(a)$	$g_3(a)$	...
b	$g_1(b)$	$g_2(b)$	$g_3(b)$	...
c	...			
...	...			
	w_1	w_2	w_3	...

Weights of the criteria

A common approach:
The weighted sum

- Global value for a :

$$V(a) = w_1\, g_1(a) + w_2\, g_2(a) + \ldots$$

- a is preferred to b if:

$$V(a) > V(b)$$

(if all criteria are to maximise)

Weighted Sum
Example 1

	g_1	g_2	g_3	g_4	g_5
a	100	100	100	100	55
b	85	85	85	85	100
	1/5	1/5	1/5	1/5	1/5

- V(a) = 91 V(b) = 88
- Total and uncontrolled compensation of weaknesses by strengthes.

Weighted Sum
Example 2

	g_1	g_2
a	100	0
b	0	100
c	50	50
d	50	50
	1/2	1/2

- $V(a) = V(b) = V(c) = V(d) = 50$
- Elimination of conflicts – Loss of information.

Weighted Sum
Example 3

"Profit is approximately 2 times more important than time savings;
0.7 for profit and 0.3 for time savings."

	g_1 (BF)	g_2 (min)
a	60	60
b	48	70
	0.7	0.3

V(*a*) = 60
V(*b*) = 54.6

a is ranked 1st.

Weighted Sum
Example 3

"Profit is approximately 2 times more important than time savings;
0.7 for profit and 0.3 for time savings."

	g_1 (FF)	g_2 (min)
a	10	60
b	8	70
	0.7	0.3

V(*a*) = 25
V(*b*) = 26.6

b is ranked 1st!

Weighted Sum

Example 3

	g_1 (BF)	g_2 (min)
a	60	60
b	48	70
	0.7	0.3

V(*a*) = 60

V(*b*) = 54.6

a is ranked 1st.

	g_1 (FF)	g_2 (min)
a	10	60
b	8	70
	0.7	0.3

V(*a*) = 25

V(*b*) = 26.6

b is ranked 1st.

→ Significance of the "weights" ! ←

Multicriteria Decision Aid

- Multiattribute utility theory (MAUT).
- Outranking methods.
- Interactive methods.
- Multiobjective programming.
- …

Since 1970, numerous developments: conferences, papers, books, applications, software...

Multiattribute Utility Theory

- Single synthesis criterion (aggregation).

$$U(a) = U(g_1(a), g_2(a), \text{K}\ , g_k(a))$$

- Existence?
- Construction?
- Mathematical form?

➔ additive?

$$U(a) = \sum_{j=1}^{k} U_j(g_j(a))$$

Multiattribute Utility Theory

- Construction method:
  - direct,
  - indirect.
- Information-intensive for the decision maker. (quantity of information vs reliability?).
- Not flexible (sensitivity analyses).
- Far away from the original decision problem structure:

multicriteria $\rightarrow$ unicriterion

Outranking Methods

- Majority principle
  (vs unanimity for dominance).
- Pairwise comparison of actions.
- Closer to the decision problem.
- **ELECTRE** methods (1968-).
- **PROMETHEE & GAIA** methods (1982-).

Tuesday 4

What? Why? How?

- What is multicriteria decision aid.
- Why you should use multicriteria decision aid:
  - Facing complexity and conflicting issues.
  - Single decision maker context.
  - Collaborative group decision.
  - Negotiations between parties or stakeholders.
- **PROMETHEE & GAIA.**

Tuesday 4

What? Why? How?

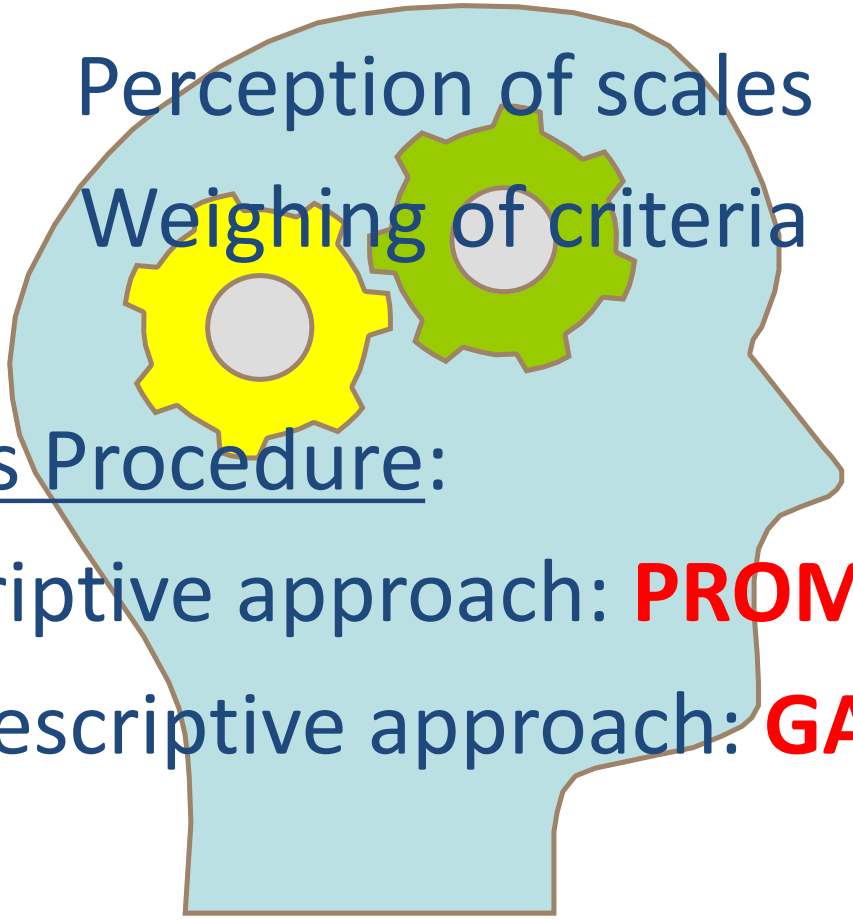
- What is multicriteria decision aid.
- Why you should use multicriteria decision aid.
- **PROMETHEE & GAIA:**
  - Data and preference modeling.
  - **PROMETHEE** rankings.
  - **GAIA** visual analysis.
  - Sensitivity analyses.
  - Group decision and negotiation.

Decision Aid Methods

- Preference modelling:

  Perception of scales

  Weighing of criteria



- Analysis Procedure:

  Prescriptive approach: **PROMETHEE**

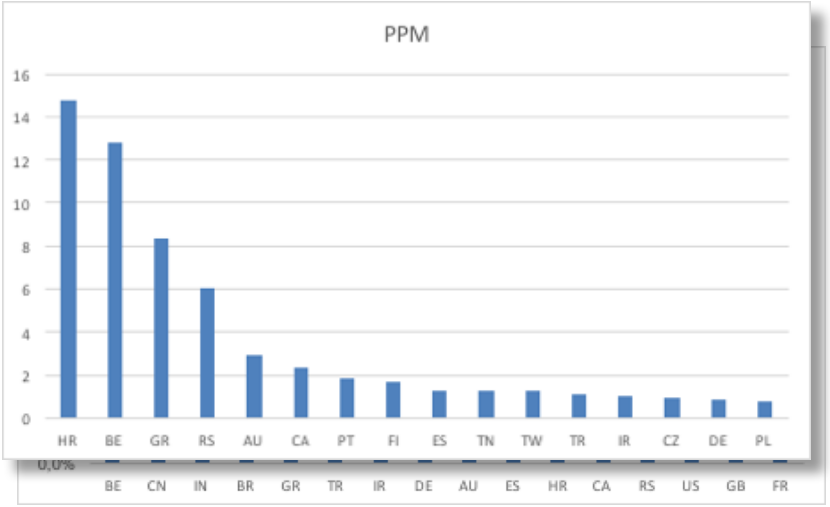
  Descriptive approach: **GAIA**

Why **PROMETHEE**?

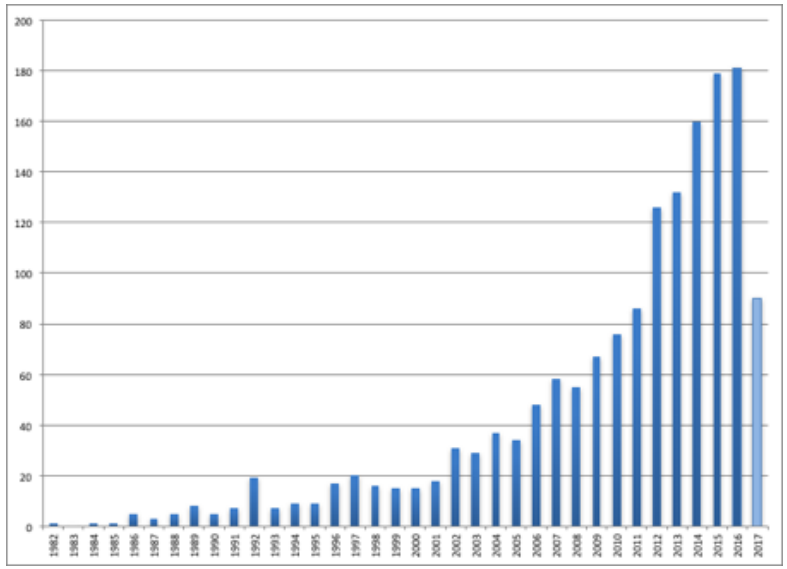
- Proven methodology:
  - 30 years development,
  - Over 1570 published scientific papers.
- « Simplicity ».
- Visual tools.
- Sensitivity analysis tools.
- Interactivity.
- **Visual PROMETHEE** software.

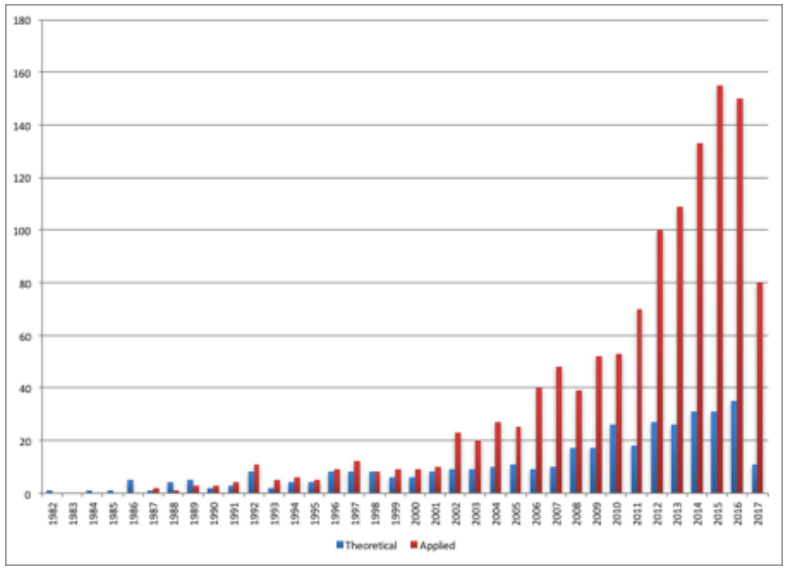
Some statistics...

- First paper published in 1982 by J-P. Brans.
- Over 1570 published papers as of today.
- 92 papers published by 153 Greek authors, from 1989 to 2017
  (worldwide #5, after Belgium, China, India and Brazil; #3 PPM)
- Main fields of application:
  - Environment
  - Industry
  - Services / Public sector
  - Energy
  - Finance



PROMETHEE Timeline





- Over 1570 papers published:
  - 75% applied – 25% theoretical
  - 55% related to “societal” fields
- Median year: 2011
- Over 2700 authors from 79 countries.

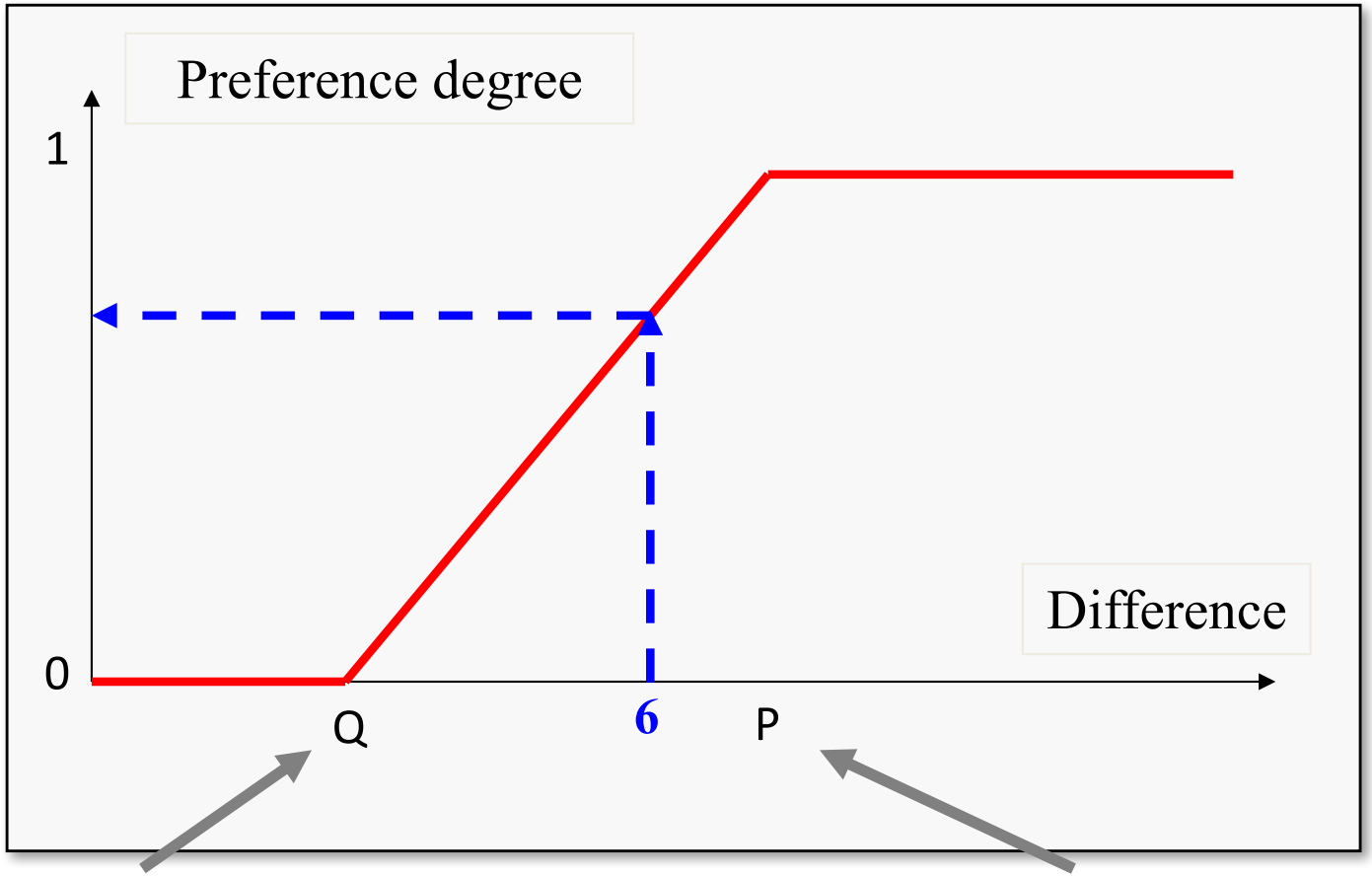
Principles of the **PROMETHEE** Methods

- Preference modelling:
  - Preference functions,
  - Weighing of the criteria.
- Pairwise comparison of the actions:
  - Outranking,
  - Prudent (partial ranking),
  - Partially compensatory approach:
    - Advantage over weighted sum and utility functions.

Comparison of 2 Actions

	Crit. 1 (/20)	Crit. 2 (rating)	Crit. 3 (qual.)	Crit. 4 (Y/N)	…
Action 1	18	135	G	Yes	…
Action 2	9	147	Difference = 6		…
Action 3	15	129	VG	No	…
Action 4	12	146	VB	?	…
Action 5	7	121	G	Yes	…
…	…	…	…	…	…

Preference Function



Indifference threshold

Linear

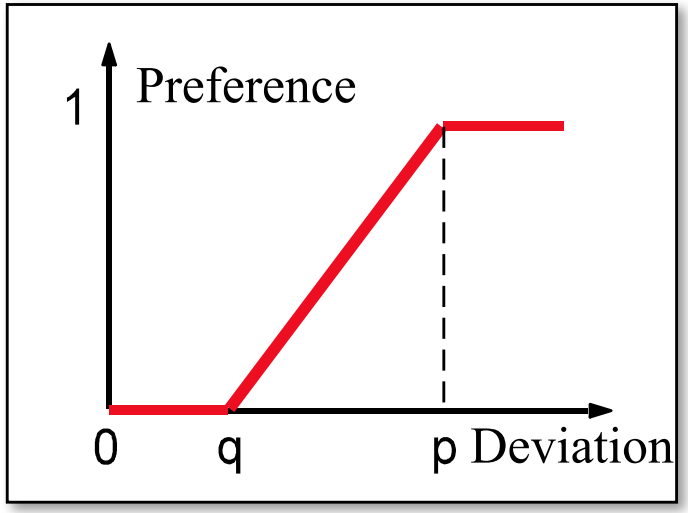
Preference threshold

PROMETHEE

Pref (Eco.,Lux.)

Pref (Lux.,Eco.)

		Economic		Luxury 1			Wght
1,0	**-23000**	15000	*Price*	38000		0,0	*1/5*
0,0		50	*Power*	90	**+40**	**1,0**	*1/5*
0,5	**-1,0**	7,5	*Fuel*	8,5		0,0	*1/5*
0,0		B	*Space*	G	**+2**	**0,5**	*1/5*
0,0		VB	*Comfort*	VG	**+4**	**1,0**	*1/5*



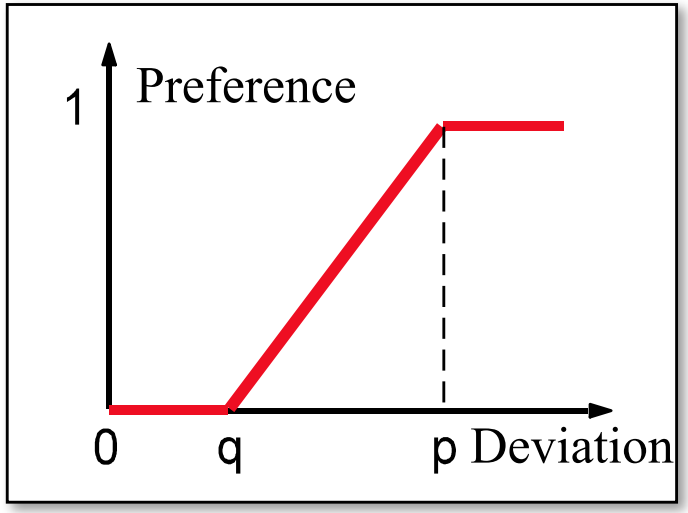
- Pref (Eco.,Lux.) = 0,3
  = (1 + 0 + 0,5 + 0 + 0) / 5
- Pref (Lux.,Eco.) = 0,5
  = (0 + 1 + 0 + 0,5 + 1) / 5

PROMETHEE

Pref (Eco.,Lux.)

Pref (Lux.,Eco.)

		Economic		Luxury 1			Wght
1,0	**-23000**	15000	*Price*	38000		0,0	*2/7*
0,0		50	*Power*	90	**+40**	**1,0**	*1/7*
0,5	**-1,0**	7,5	*Fuel*	8,5		0,0	*2/7*
0,0		B	*Space*	G	**+2**	**0,5**	*1/7*
0,0		VB	*Comfort*	VG	**+4**	**1,0**	*1/7*



- Pref (Eco.,Lux.) = 0,43
  = (2 x 1 + 0 + 2 x 0,5 + 0 + 0) / 7
- Pref (Lux.,Eco.) = 0,36
  = (0 + 1 + 0 + 0,5 + 1) / 7

Pairwise Comparisons

- For each criterion g_j :
  - Preference function P_j
  - Weight w_j
- Multicriteria preference degree of a over b :

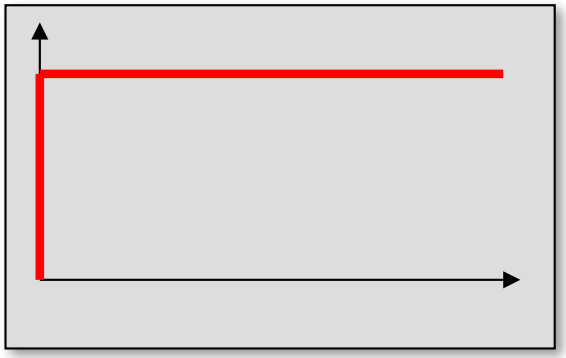
$$\pi(a,b) = \sum_{j=1}^{k} w_j \, P_j(a,b)$$

  - Properties:

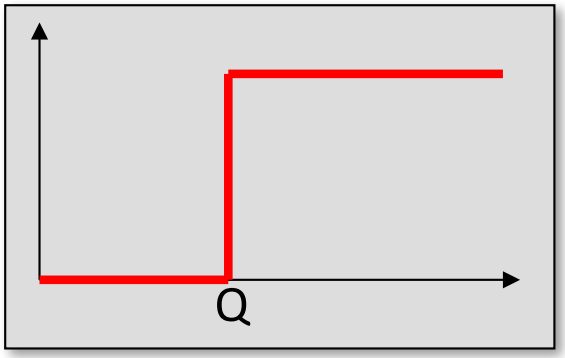
$$0 \leq \pi(a,b) \leq 1$$

$$\pi(a,b) > 0 \Rightarrow \pi(b,a) = 0$$

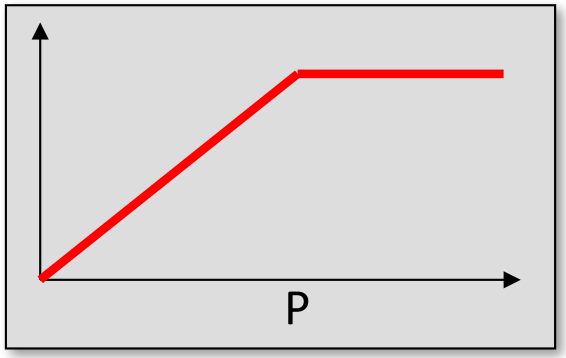
Preference Functions
(as in **Visual PROMETHEE** software)



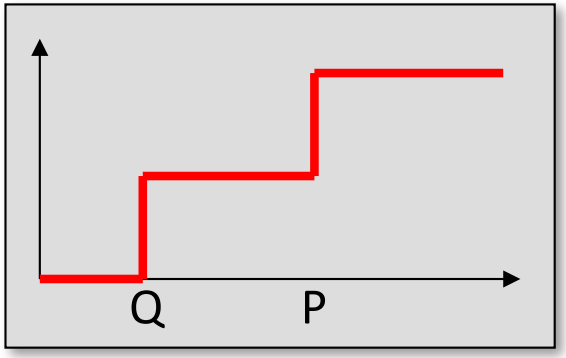
Usual



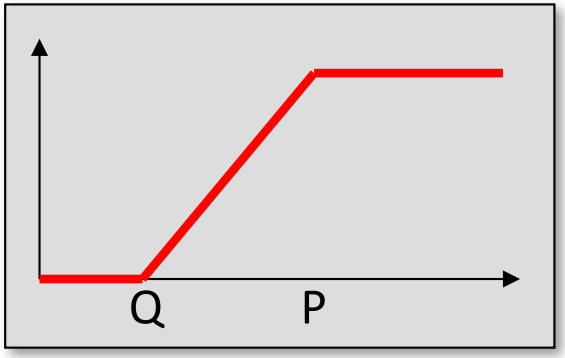
U-shape



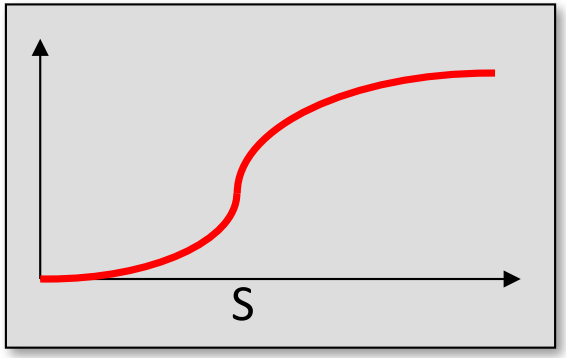
V-shape



Level



Linear



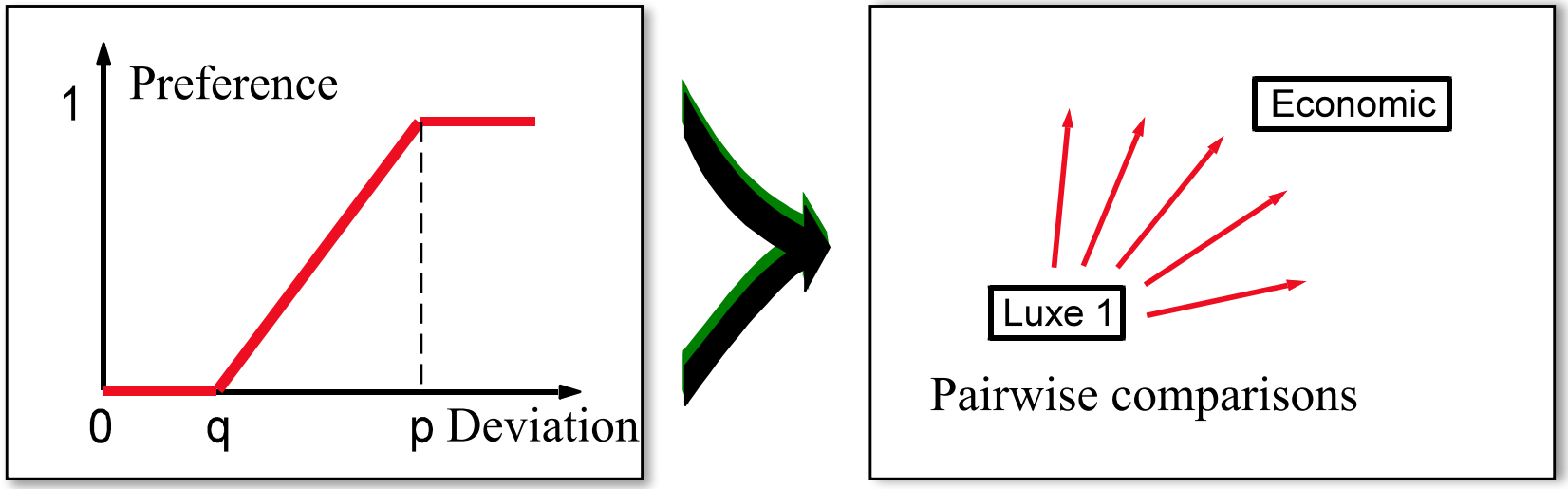
Gaussian

PROMETHEE

Pref (Eco.,Lux.)

Pref (Lux.,Eco.)

		Economic		Luxury 1		
1,0	**-23000**	15000	*Price*	38000		0,0
0,0		50	*Power*	90	**+40**	**1,0**
0,5	**-1,0**	7,5	*Fuel*	8,5		0,0
0,0		B	*Space*	G	**+2**	**0,5**
0,0		VB	*Comfort*	VG	**+4**	**1,0**



Computation of Preference Flows

$\pi(a,b)$	*Tour.A*	*Sport*	*Tour.B*	*Lux.*1	*Econ.*	*Lux.*2	$\phi^+(a)$
Tour.A	0,00	0,34	0,00	0,21	0,26	0,22	0,21
Sport	0,20	0,00	0,16	0,24	0,30	0,24	0,23
Tour.B	0,15	0,55	0,00	0,32	0,45	0,33	0,36
*Lux.*1	0,18	0,45	0,10	0,00	0,50	0,15	0,28
Econ.	0,20	0,34	0,14	0,30	0,00	0,35	0,27
*Lux.*2	0,24	0,30	0,10	0,04	0,60	0,00	0,26
$\phi^-(a)$	0,19	0,40	0,10	0,22	0,42	0,26	
$\phi(a)$	0,02	-0,17	0,26	0,06	-0,15	0,00	

Preference Flows

- Relative scores computed for the actions.
- Leaving (+) and entering (–) flows:
  - Strength: $\mathbf{0} \leq \phi^{+} \leq \mathbf{1}$
  - Weakness: $\mathbf{0} \leq \phi^{-} \leq \mathbf{1}$
- Net flow:
  - Balance: $-\mathbf{1} \leq \phi = \phi^{+} - \phi^{-} \leq +\mathbf{1}$
- Unicriterion net flows:
  - Standardized scores for each criterion:

$$\text{criterion } f_j \quad \Rightarrow \quad -\mathbf{1} \leq \phi_j \leq +\mathbf{1}$$

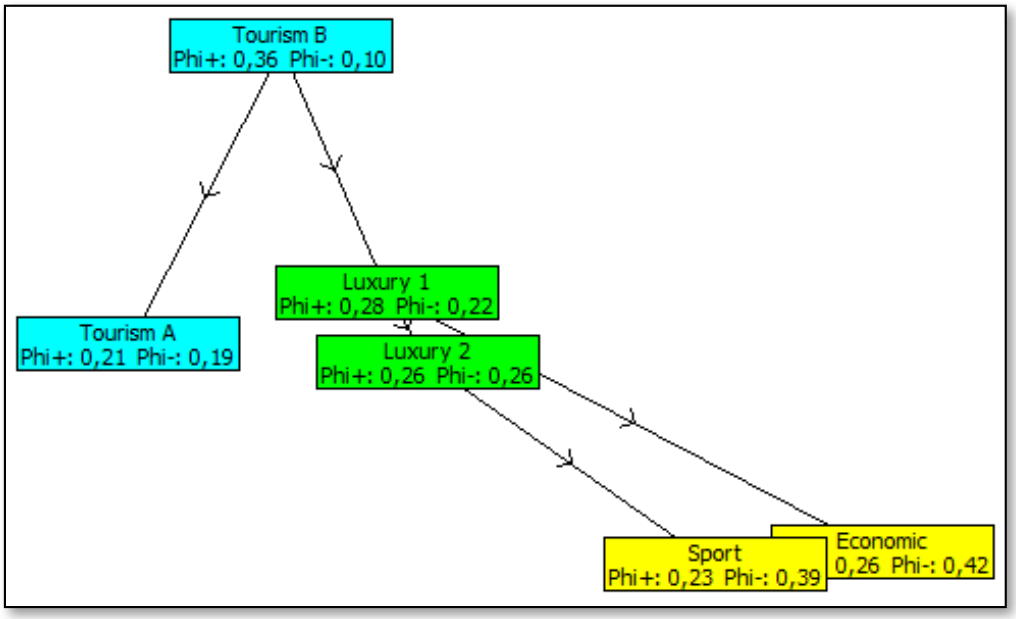
Wednesday 5

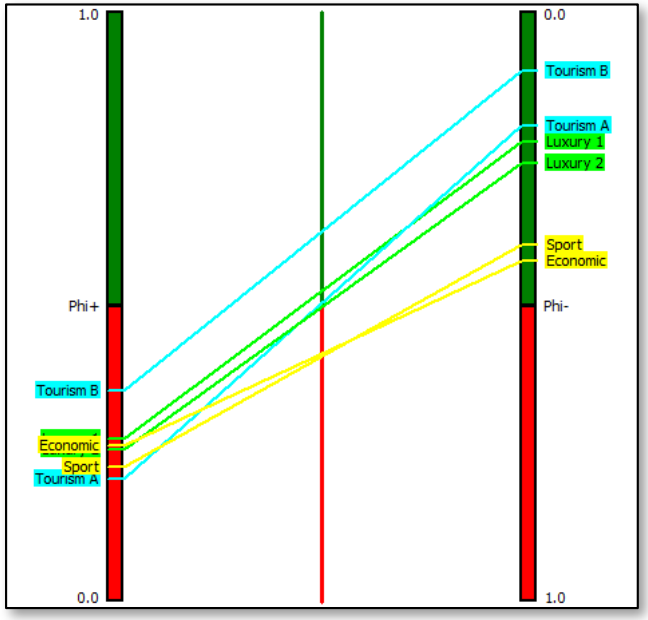
The Software

- Advanced features.
- Using **PROMETHEE** and the **Visual PROMETHEE** software.
- Hands-on training.

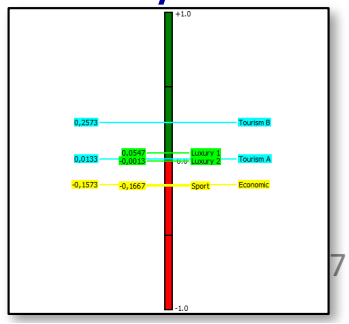
PROMETHEE I & II

- **PROMETHEE I** : partial ranking – ϕ^+, ϕ^-

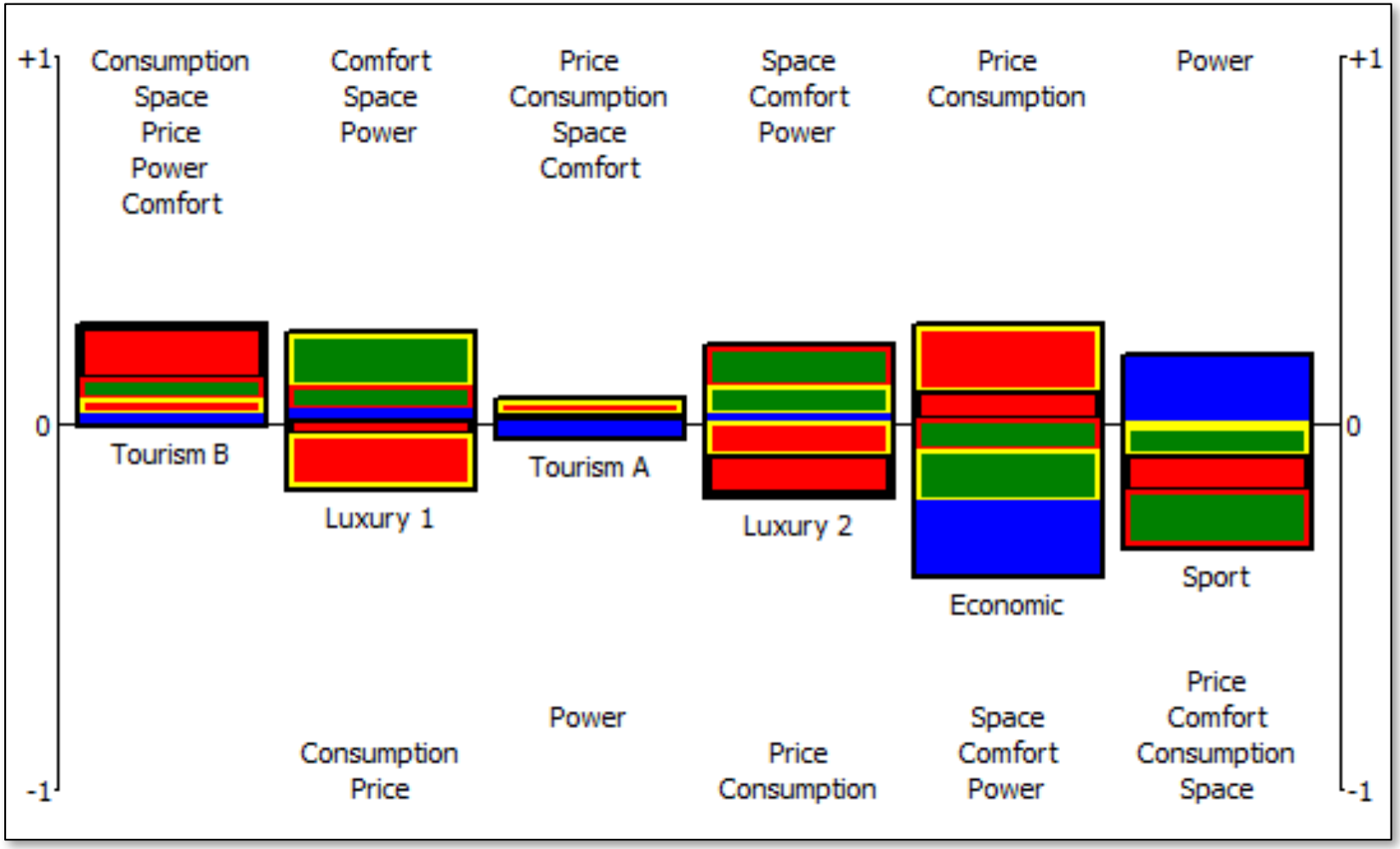




- **PROMETHEE II** : complete ranking – ϕ



PROMETHEE Rainbow

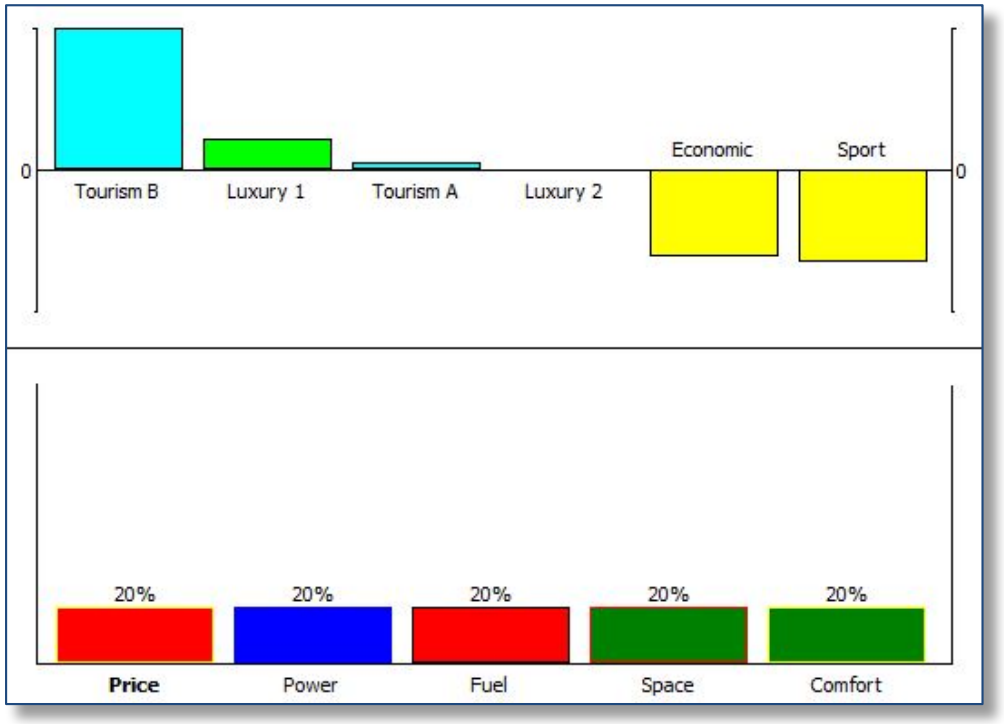


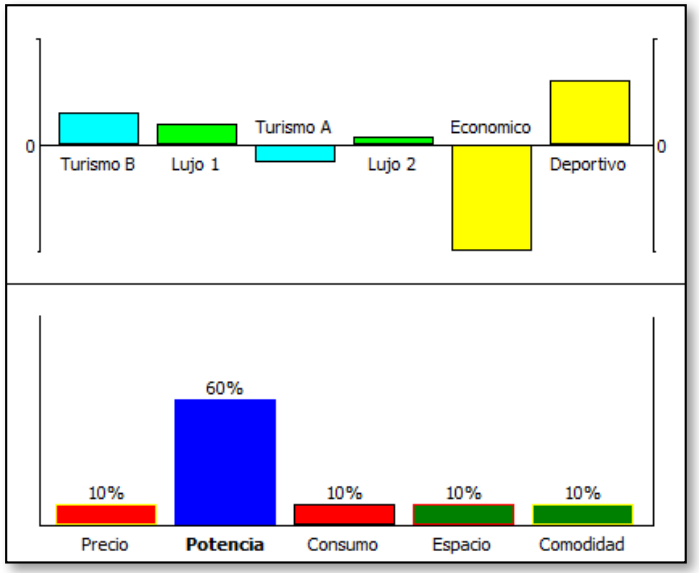
Net flow decomposition by criterion

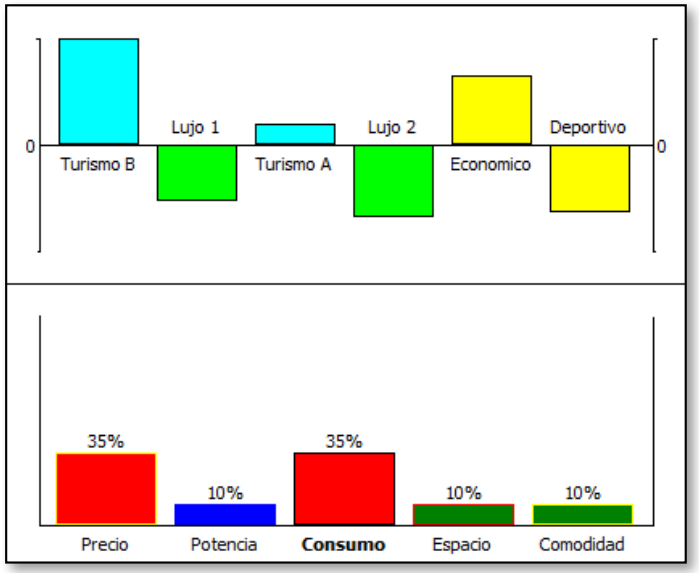
Sensitivity Analysis with **PROMETHEE**

- Criteria weights ↔ **PROMETHEE** ranking.
- Interactive weight sensitivity analysis:
  « Walking Weights ».
- Robustness with respect to weight values?
  - Weight stability intervals.
  - Visual weight stability intervals.

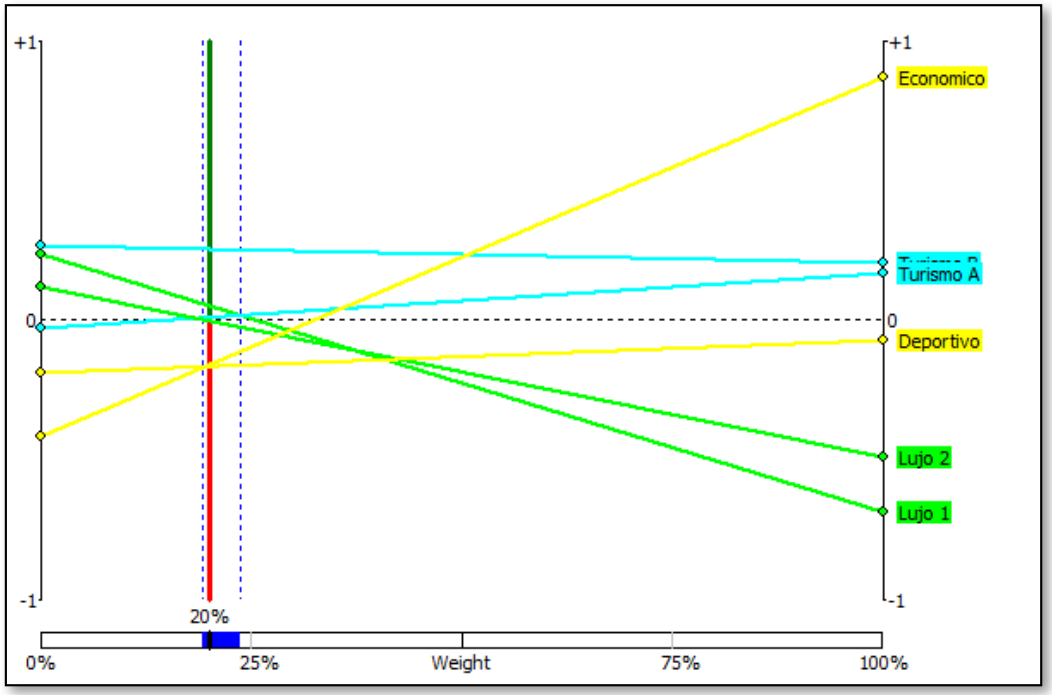
Walking Weights



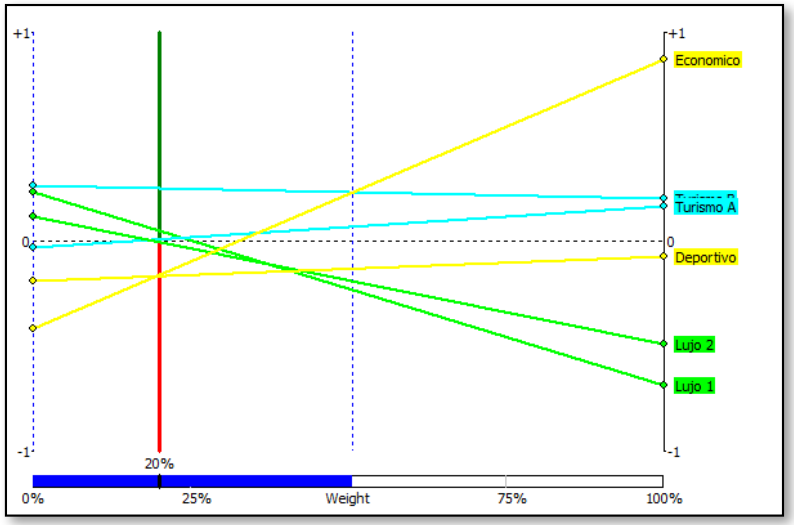




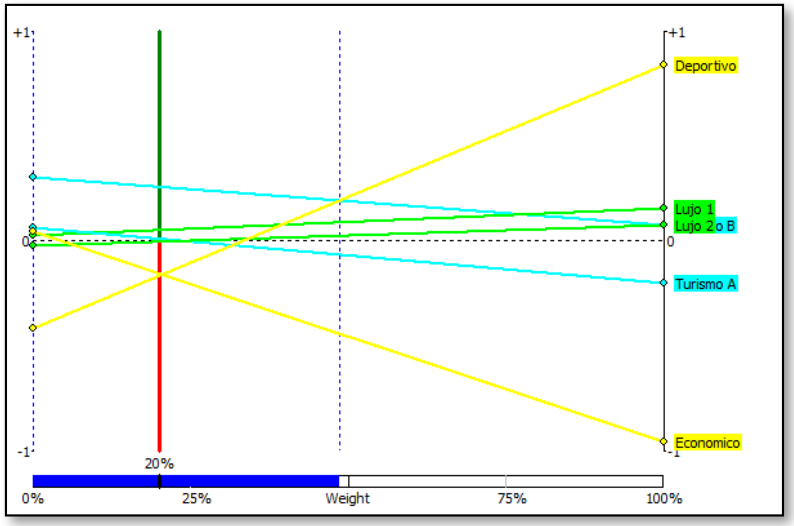
Visual Stability Intervals



VSI for « Price » (level 6):
[19.20% , 23.70%]



VSI for « Price » (level 1): [0.00% , 50.68%]



VSI for « Power » (level 1): [0.00% , 48.65%]

Limits of a Ranking Method

- Robustness of the ranking?
- « Blind » sensitivity analysis.
- Closely ranked actions can have quite different profiles.
- Origin of incomparabilities?

➢ Usefulness of a complementary descriptive approach.

Properties of the Net Flow

- Net flow is centered: $\sum_{a \in A} \phi(a) = 0$

- Unicriterion net flows:

$$\phi(a) = \sum_{j=1}^{k} w_j \cdot \phi_j(a)$$

with

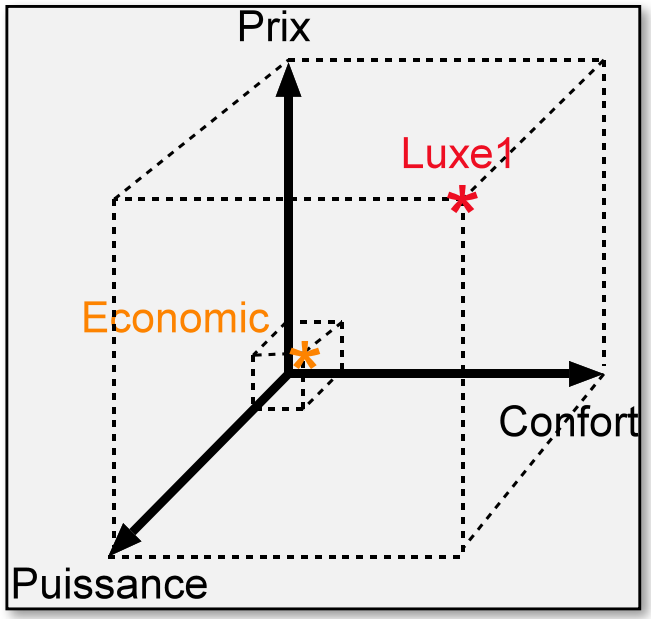
$$\phi_j(a) = \frac{1}{n-1} \sum_{b \in A} \left[P_j(a,b) - P_j(b,a) \right]$$

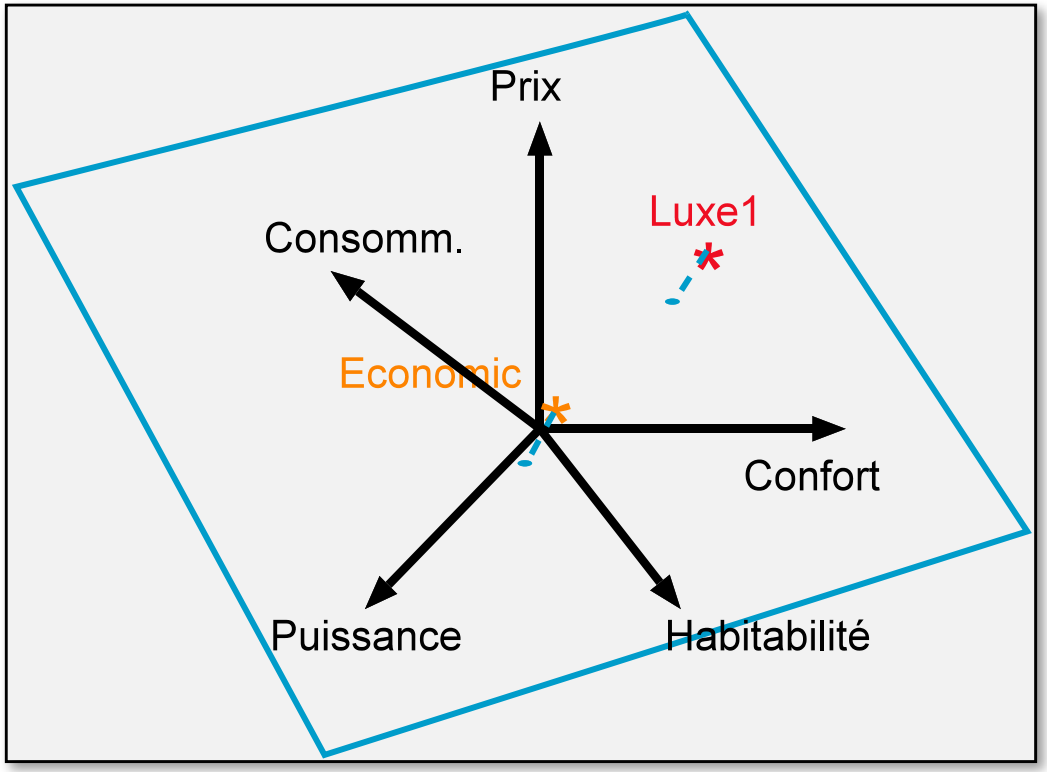
GAIA

- Visual descriptive analysis.
- Better understanding:
  - Conflicting criteria.
  - Action profiles.
  - Possible compromise solutions.
- Reducing the multicriteria dimension:
  - Principal components analysis.

GAIA

1. **Computation of unicriterion net flows (normalization)**
2. **Projection on a plane:**

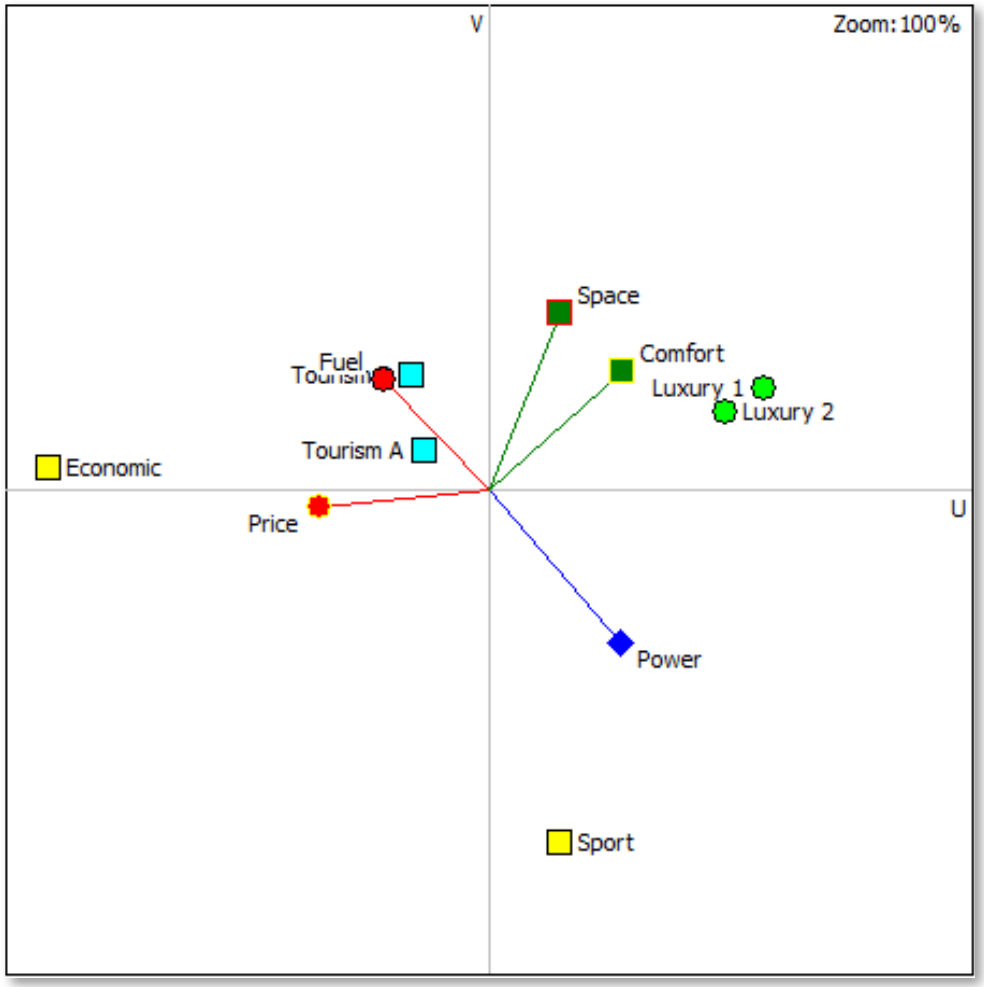




- Graphical representation.
- 5 dimensions!

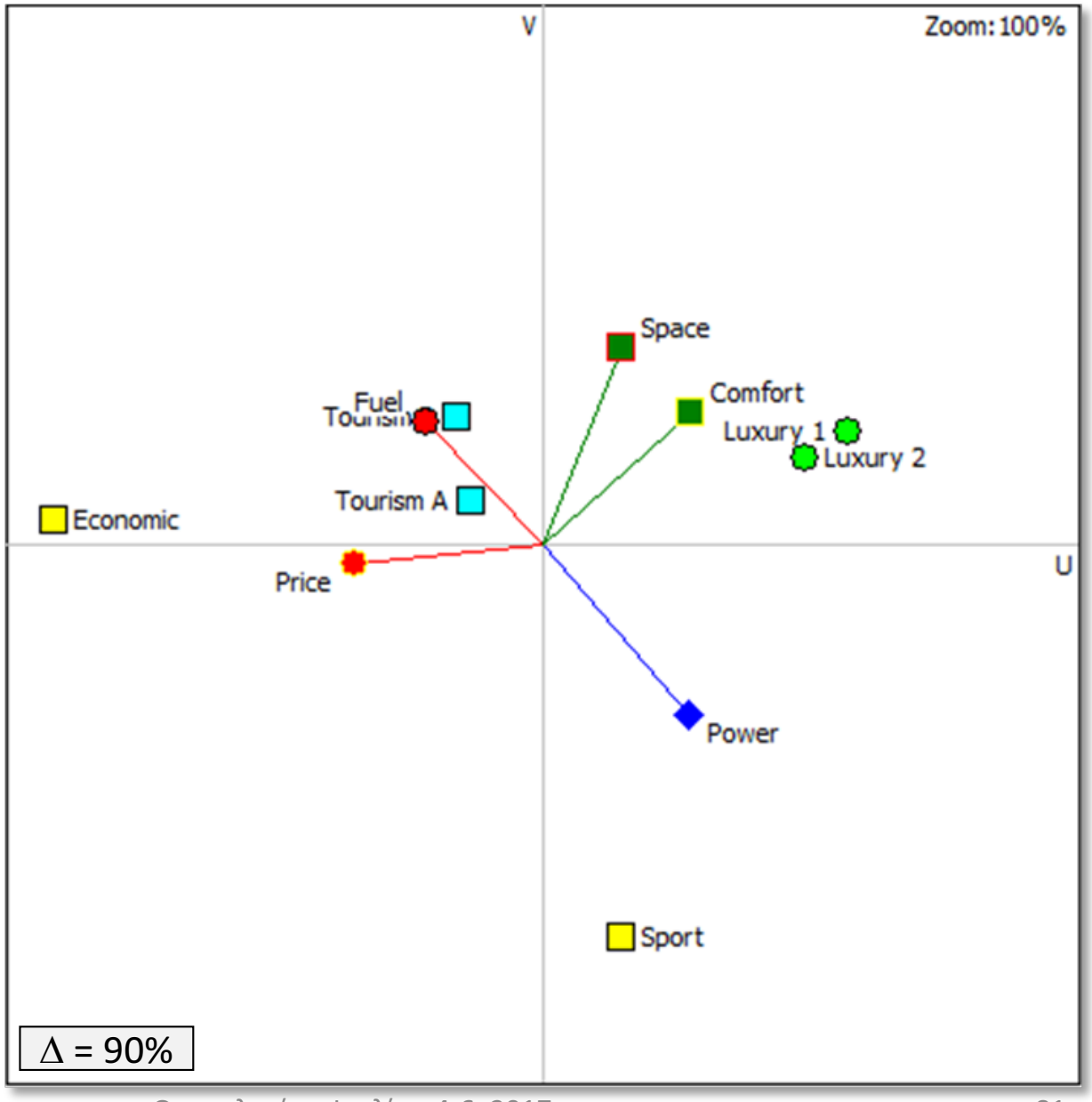
GAIA

- Discover conflicts among criteria.
- Identify potential compromises.
- Help to fix priorities.



GAIA

- Actions: points
- Criteria: axes

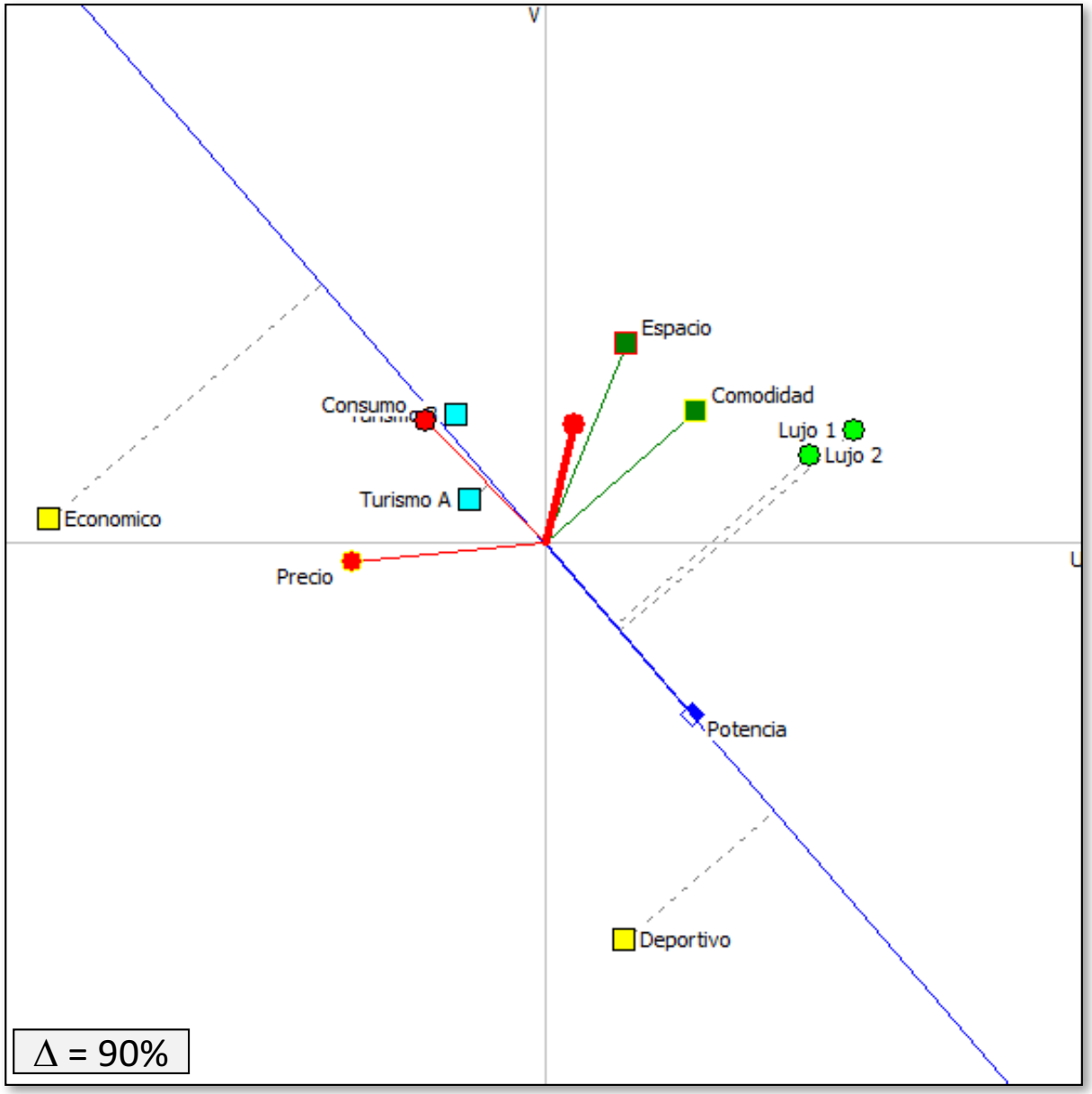


GAIA

Price

- Economic: 15 k€
- Tourism: 25,5-26 k€
- Sport: 29 k€
- Luxury: 35-38 k€

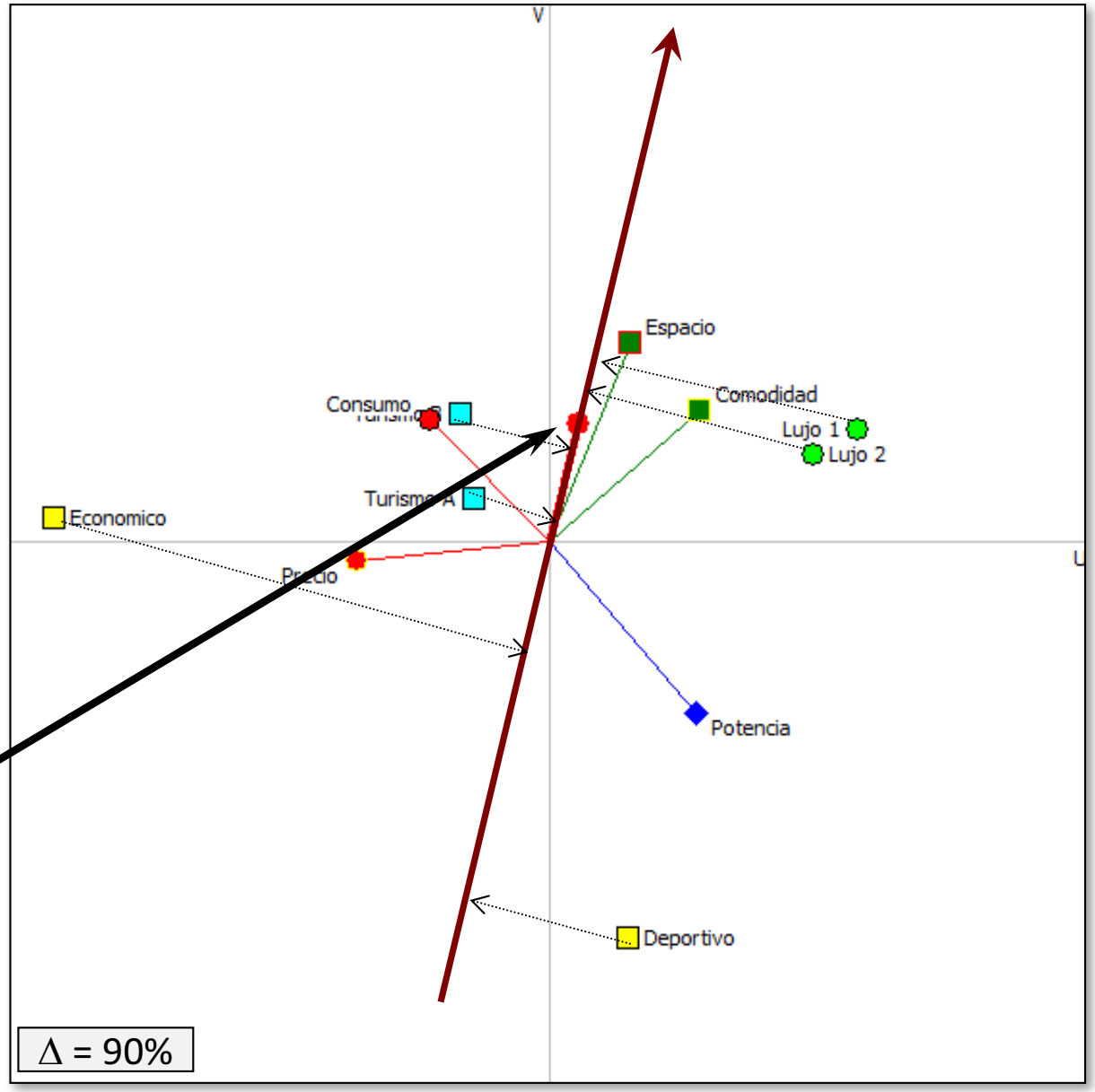
GAIA



Power

- Sport: 110 kW
- Luxury: 85-90 kW
- Tourism: 75-85 kW
- Economic: 50 kW

GAIA

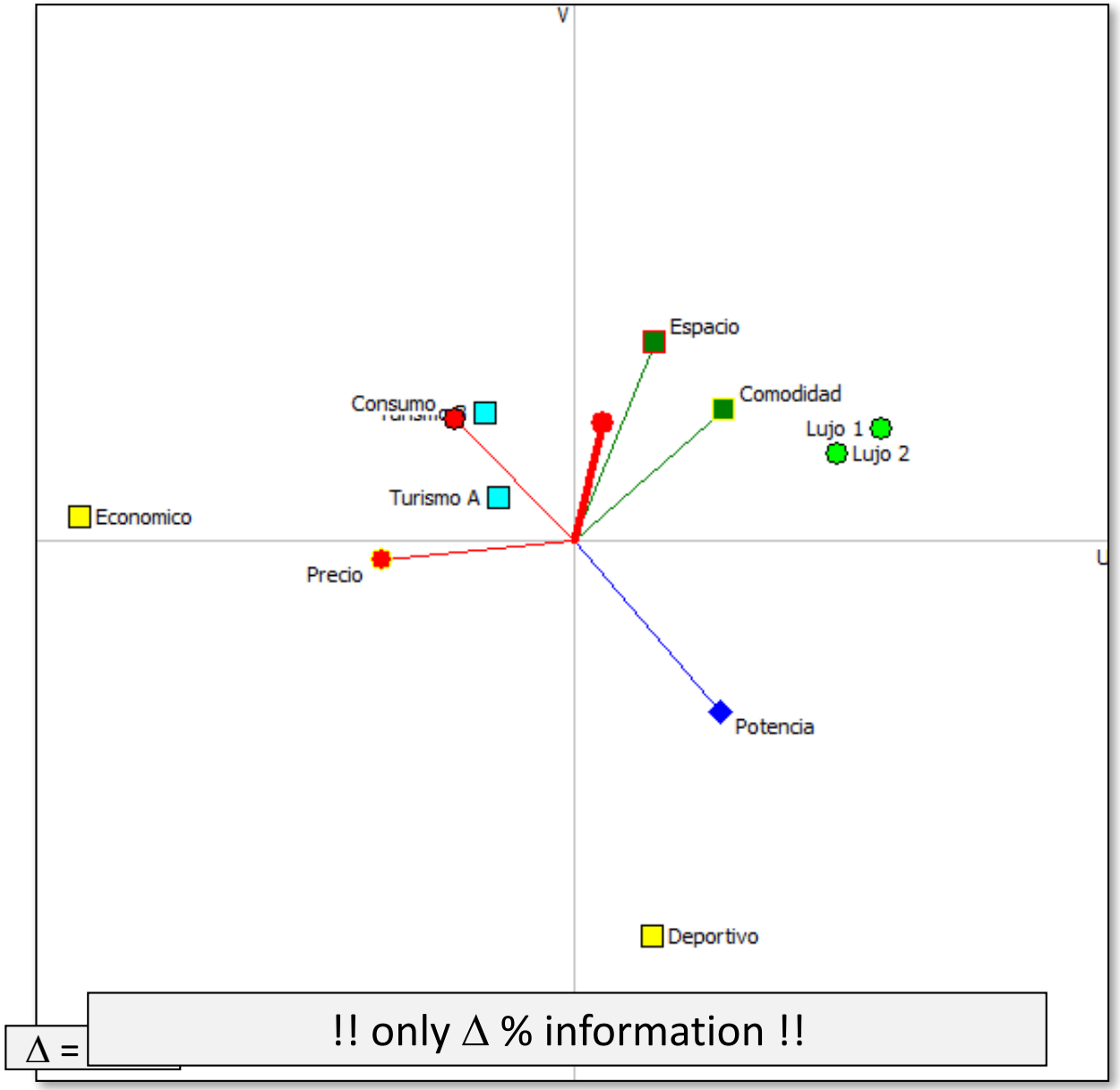


PROMETHEE II !

- Tourism B : 0,26
- Luxury 1 : 0,06
- Tourism A : 0,02
- Luxury 2 : 0,00
- Economic : -0,15
- Sport : -0,17

GAIA

- Actions: points
- Criteria: axes
- Decision axis



What is important in **GAIA**?

- Quality (Δ) of the representation:

  $\Delta < 60\%$ **$60\% \leq \Delta \leq 75\%$** **$\Delta > 75\%$**

- Direction of the criteria axes:
  - Groups of criteria expressing similar preferences (potential redundancies…).
  - Conflicting criteria.
- Length of the criteria axes:
  - Shorter: less discriminant criterion.
  - Longer: more discriminant criterion.
- Position of the actions:
  - Clusters of actions with similar profiles.
  - Position with respect to the **direction** of (not the proximity to) the criteria axes : strengths and weaknesses.

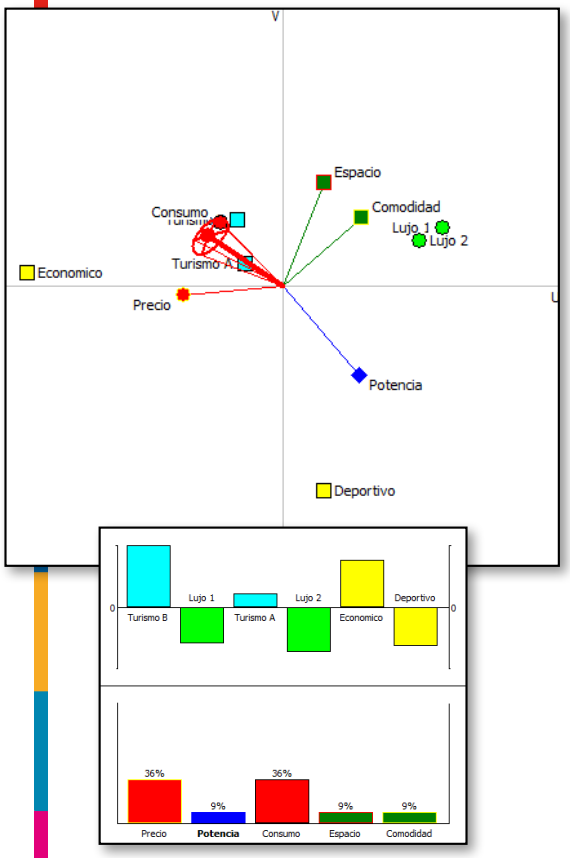
Sensitivity Analysis with **GAIA**

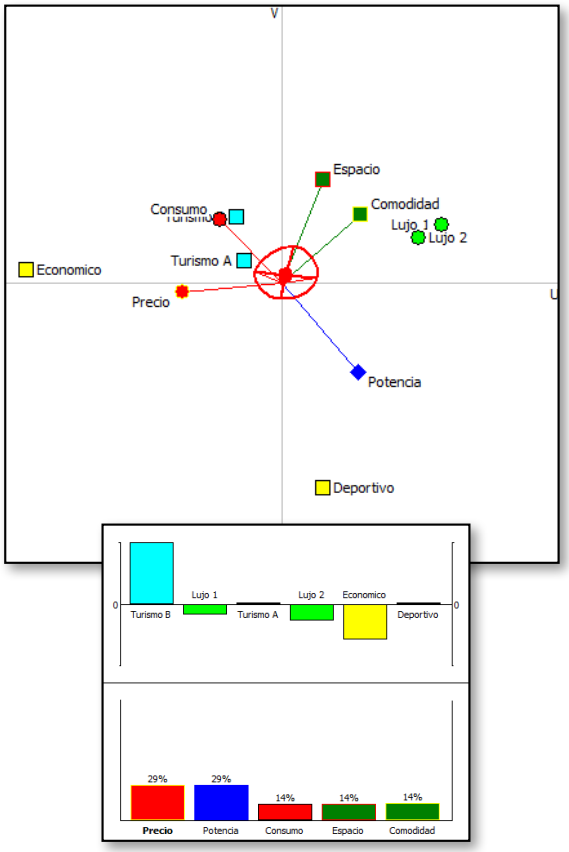
- Criteria weights ↔ Decision axis position.
- Interactive weight sensitivity analysis:
  « Walking Weights ».
- Robustness with respect to weight values?
  - Decision maker « brain » (**PROMETHEE VI**).
  - Area determined by the tip of the decision axis when criteria weights are changed within predefined percentages.

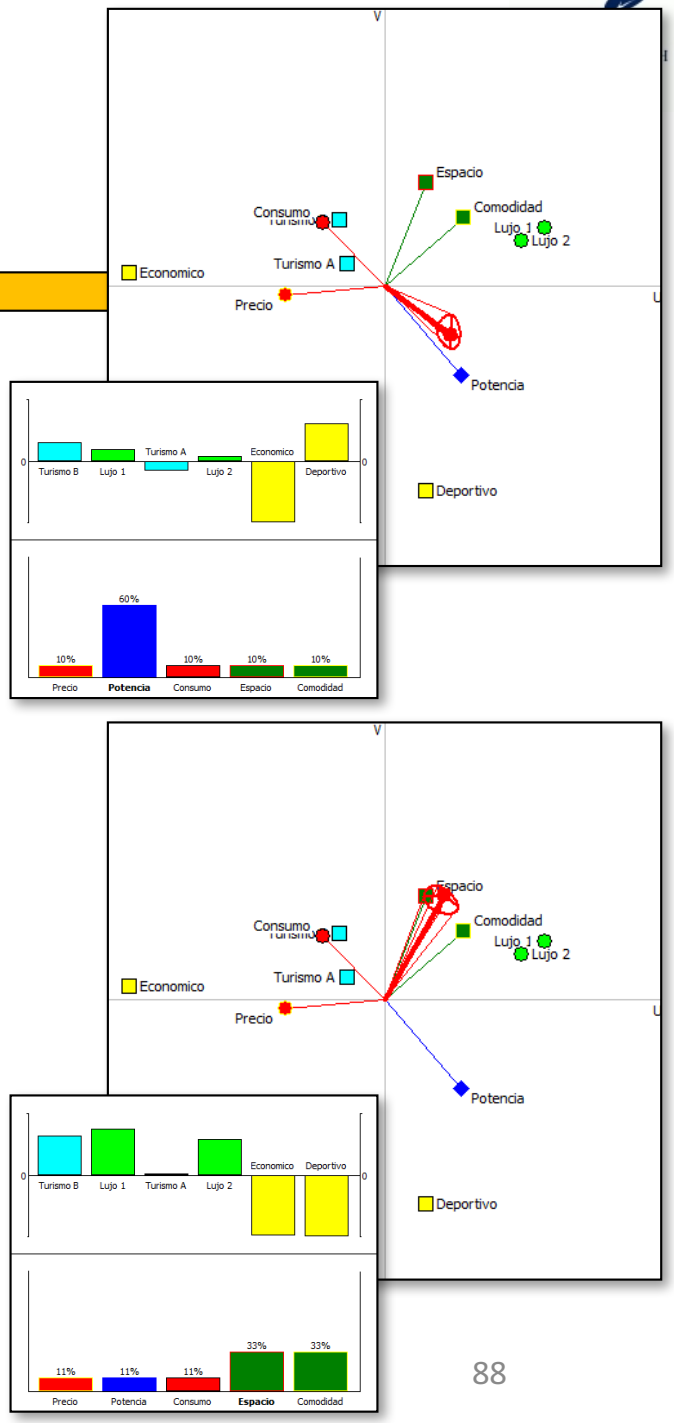
GAIA-Brain

20 years old

35 years old



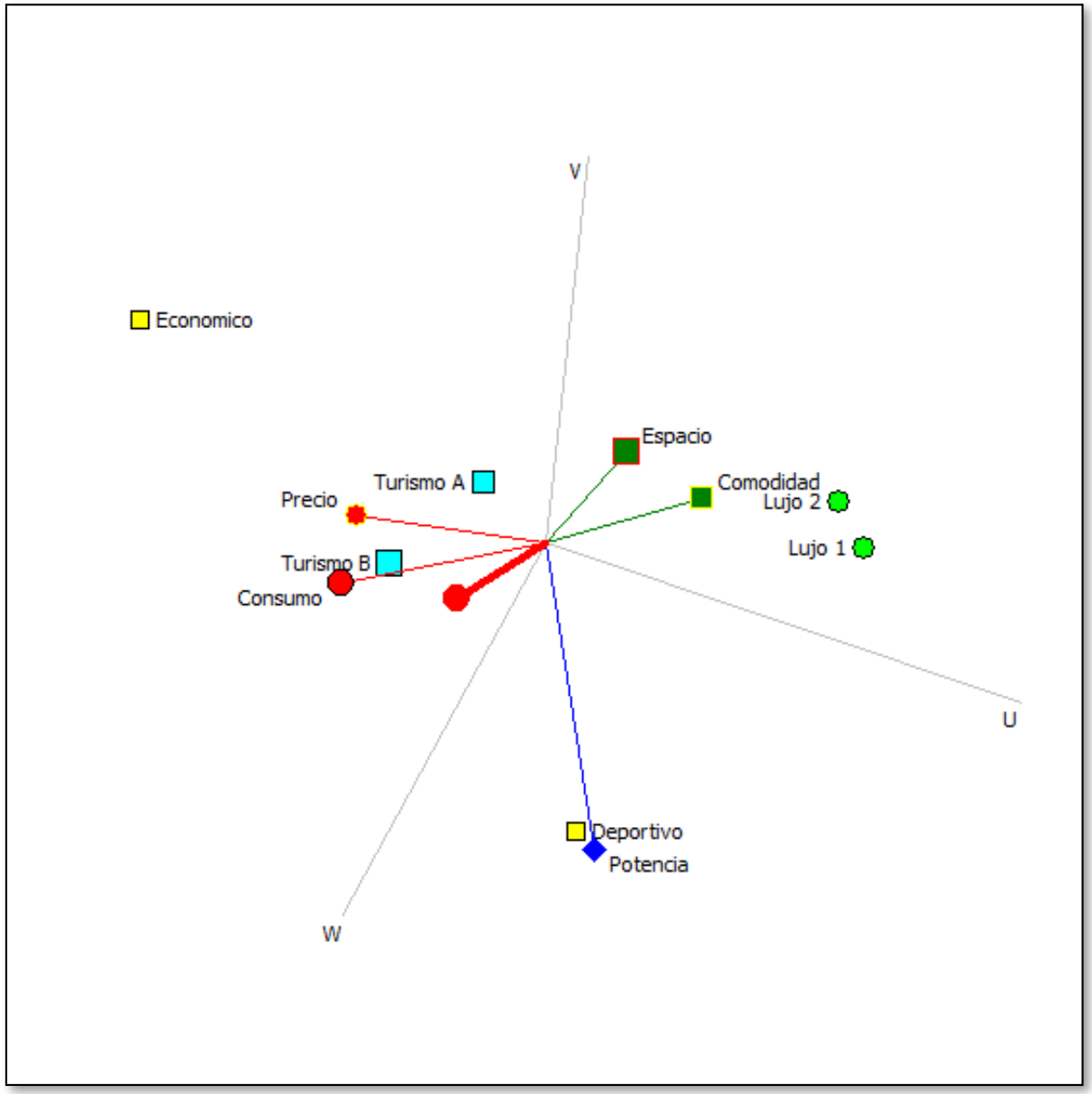




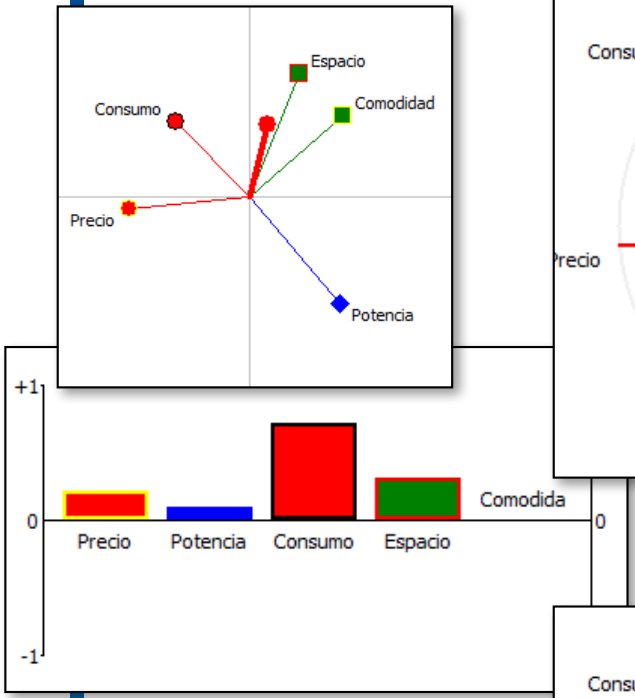
Enhancing **GAIA**

- Limits of **GAIA**:
  - Imperfect view of the multicriteria data (Δ%).
  - Potential distortion of the action profiles.
  - Non-optimal representation of the decision axis (weights) and distortion of the **PROMETHEE II** ranking (especially when the decision axis is shorter).
- New« **GAIA**-type » views:
  - **GAIA** 3D
  - **GAIA** Webs

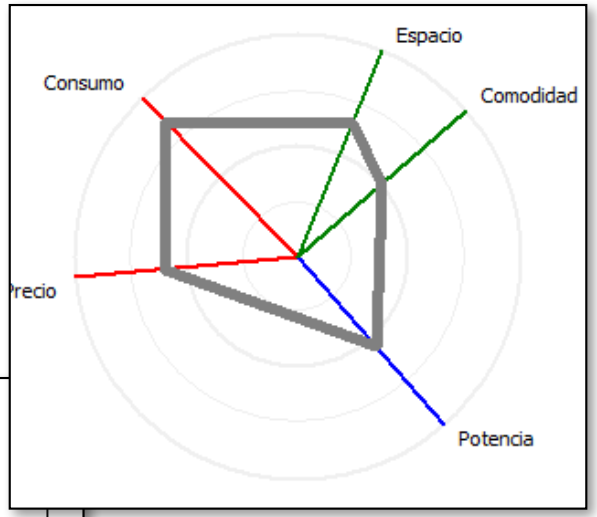
GAIA 3D


V
Economico
Espacio
Turismo A
Precio
Comodidad
Lujo 2
Lujo 1
Turismo B
Consumo
U
Deportivo
Potencia
W

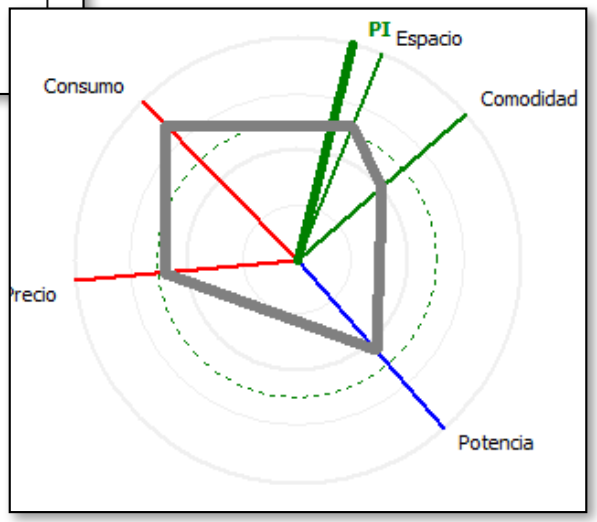
GAIA Webs

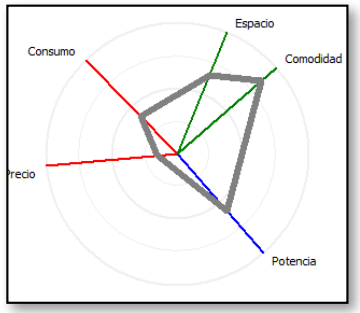


Action profile – Tourism B

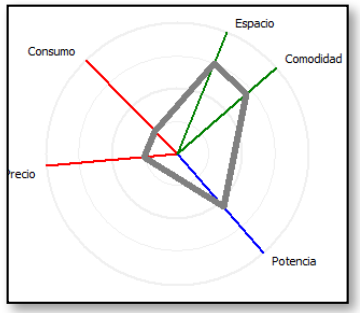


GAIA Web – Tourism B

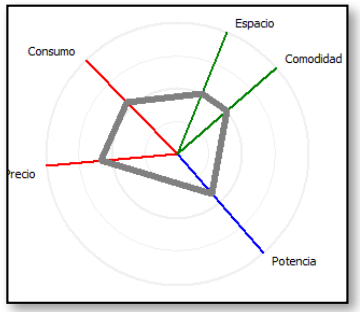




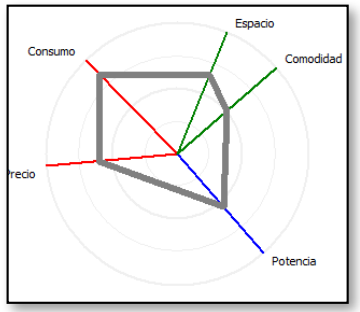
Luxury 1



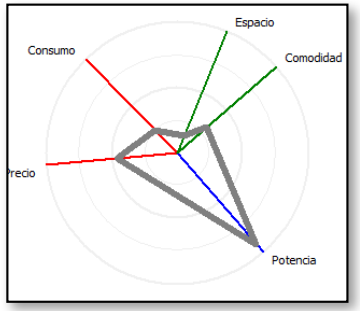
Luxury 2



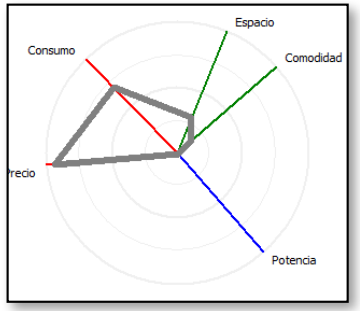
Tourism A



Tourism B



Sport



Economic

Multi-scenarios Model

- Scenarios:
  - Points of view,
  - Hypotheses, …
- Evaluations:
  - ‘Objective’ criteria: common evaluations.
  - ‘Subjective’ criteria: specific evaluations for each scenario.
- Specific preference structures :
  - Weights, preference thresholds.

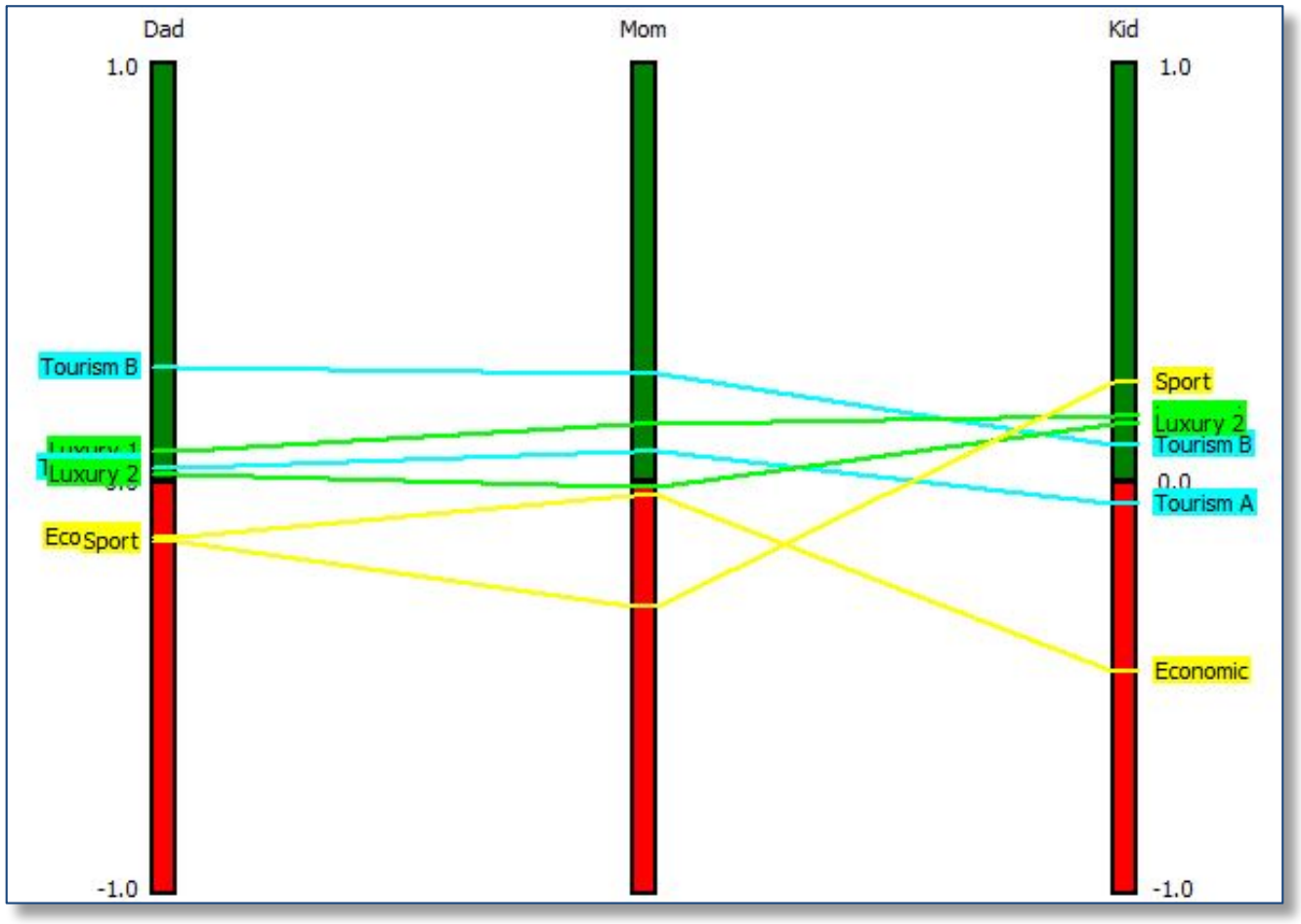
Multi-scenarios Model

- Adaptation of **PROMETHEE**:
  - Individual rankings,
  - Global (group) ranking with possible weighing of the scenarios.
- Adaptation of **GAIA**:
  - Three different analyses:
    - **GAIA**-Criteria,
    - **GAIA**-Scenarios,
    - **GAIA**-Unicriterion.

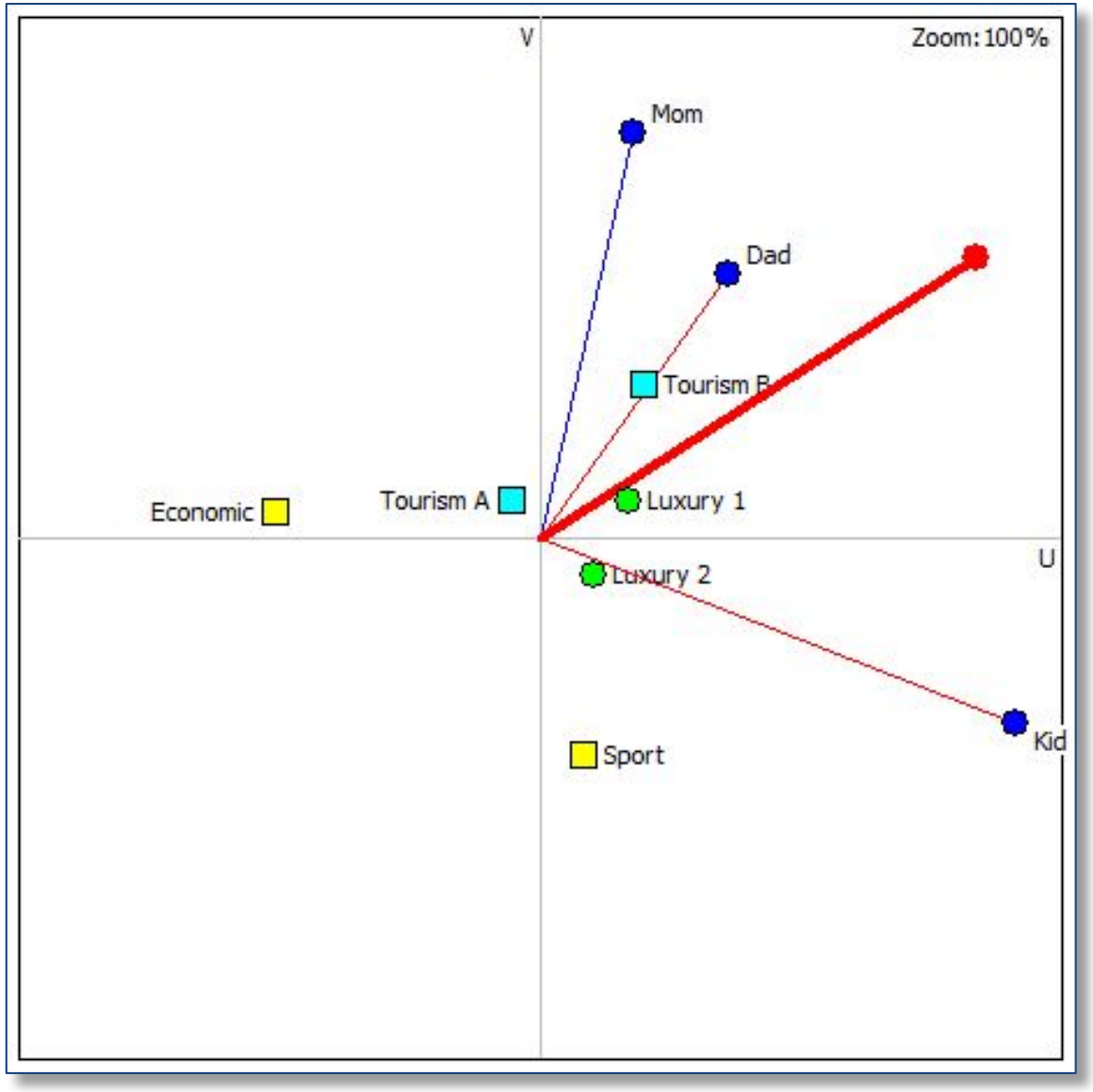
Example

- A Greek family.
- Three actors (“decision makers”):
  - Ιάσων (dad),
  - Ελευθερία (mom),
  - Γιώργος (the kid).
- Three scenarios.
- Three multicriteria tables:
  - Different weights.
  - Subjective evaluation of comfort.

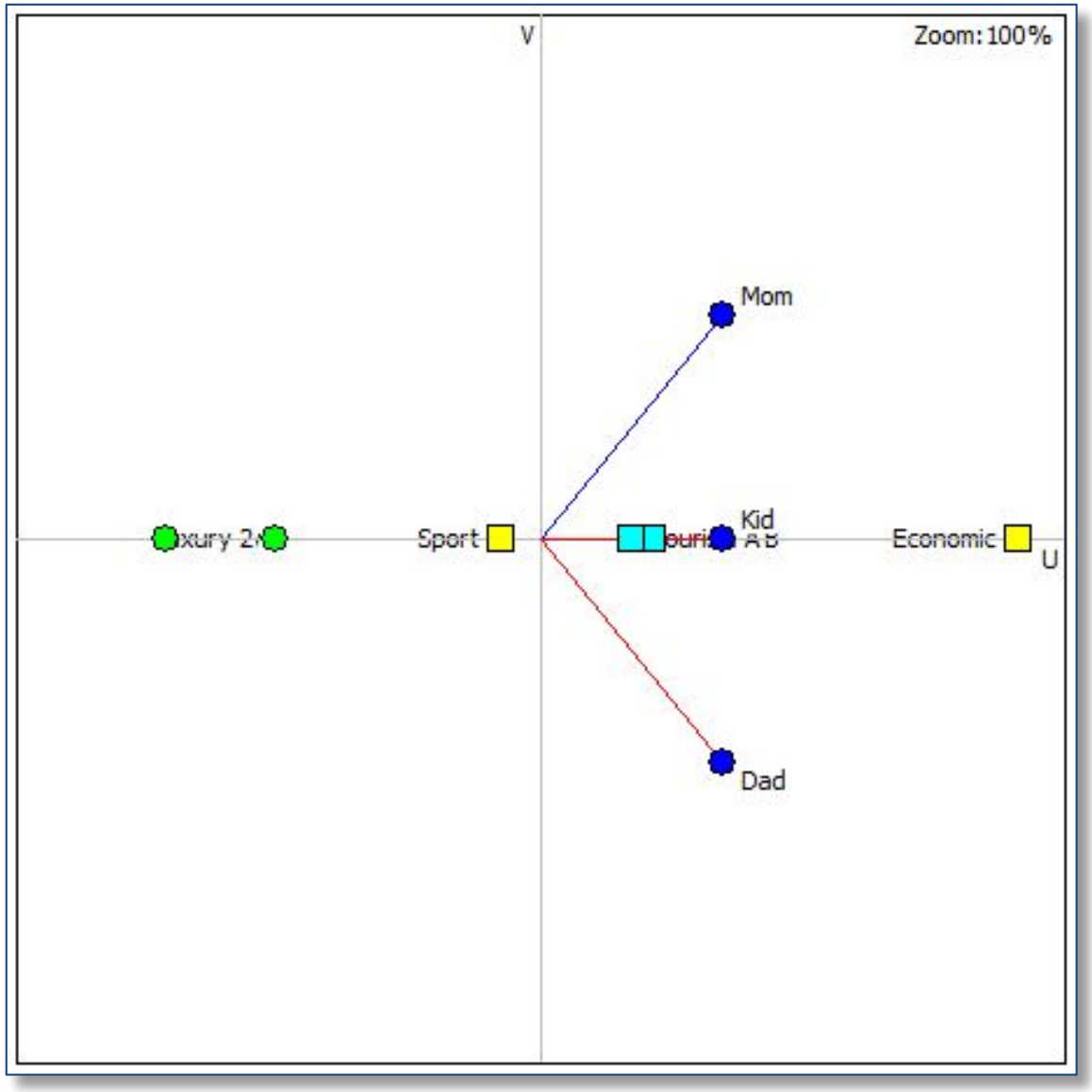
Individual **PROMETHEE** rankings



GDSS-**GAIA**: Scenarios

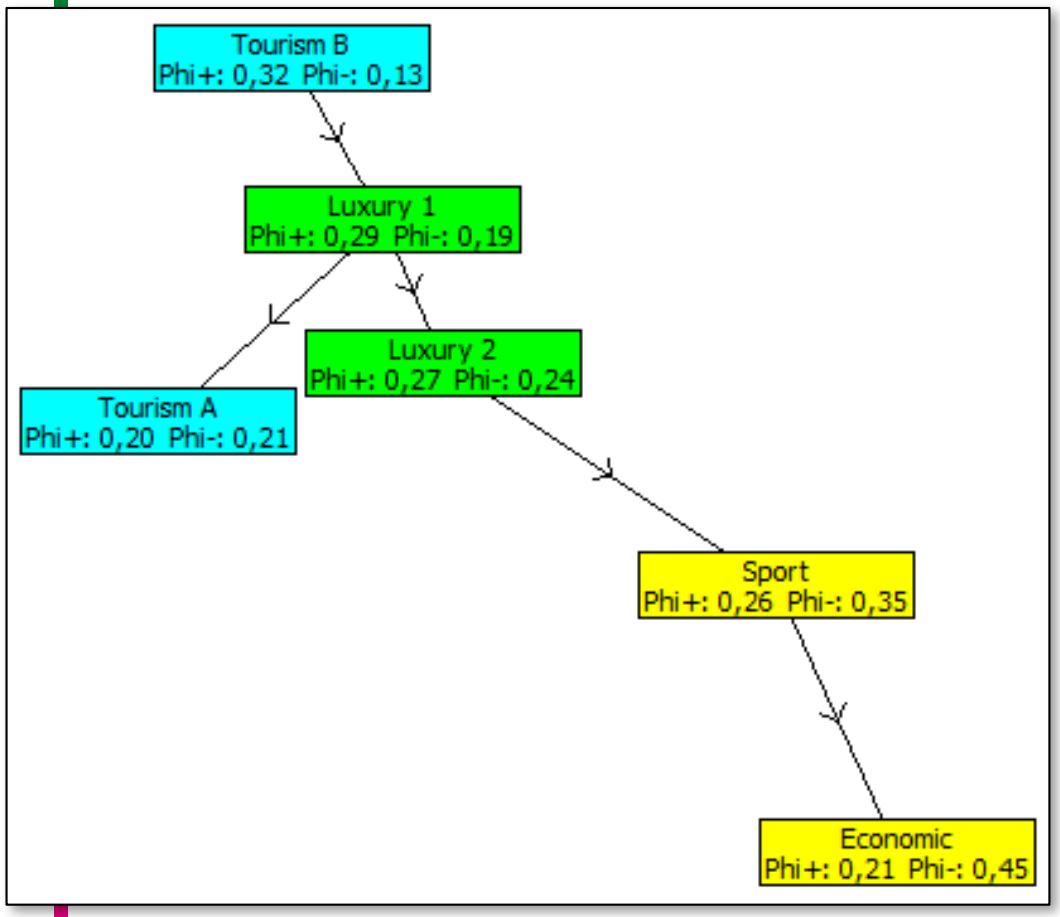


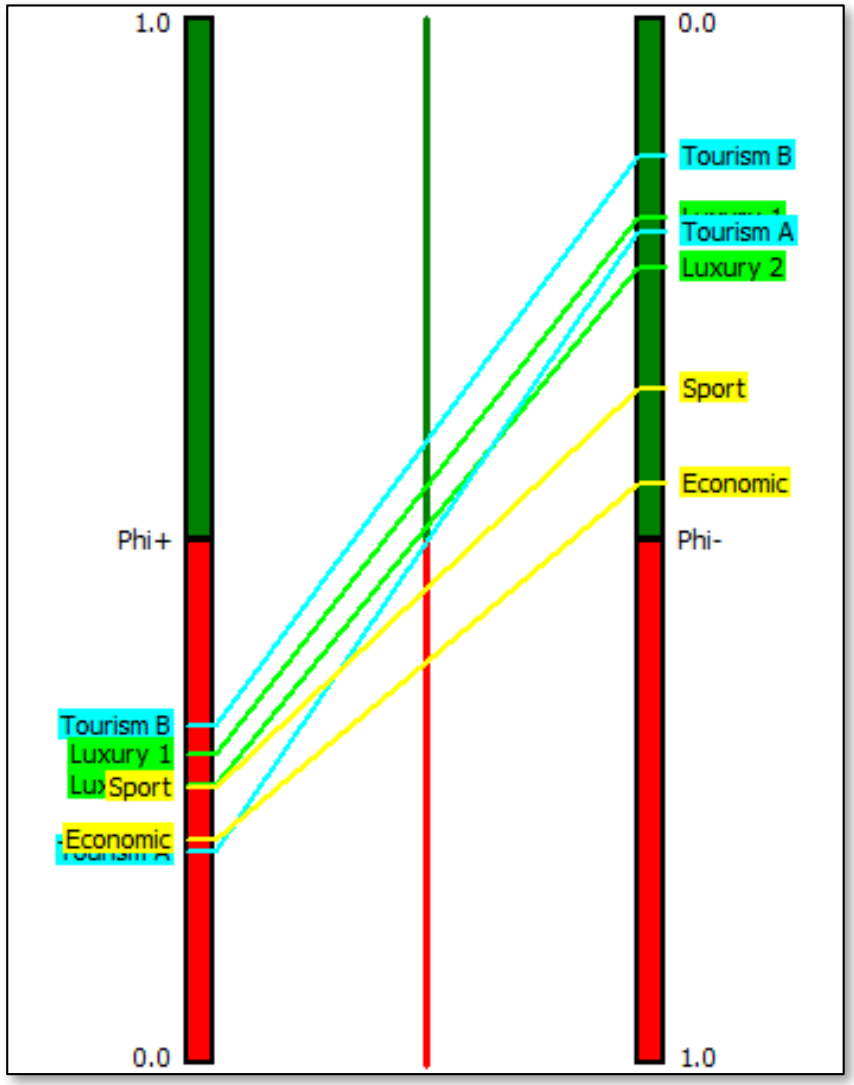
GDSS-**GAIA**: Criterion Price



GDSS-**GAIA**: Criterion Comfort

« Family » (group) ranking

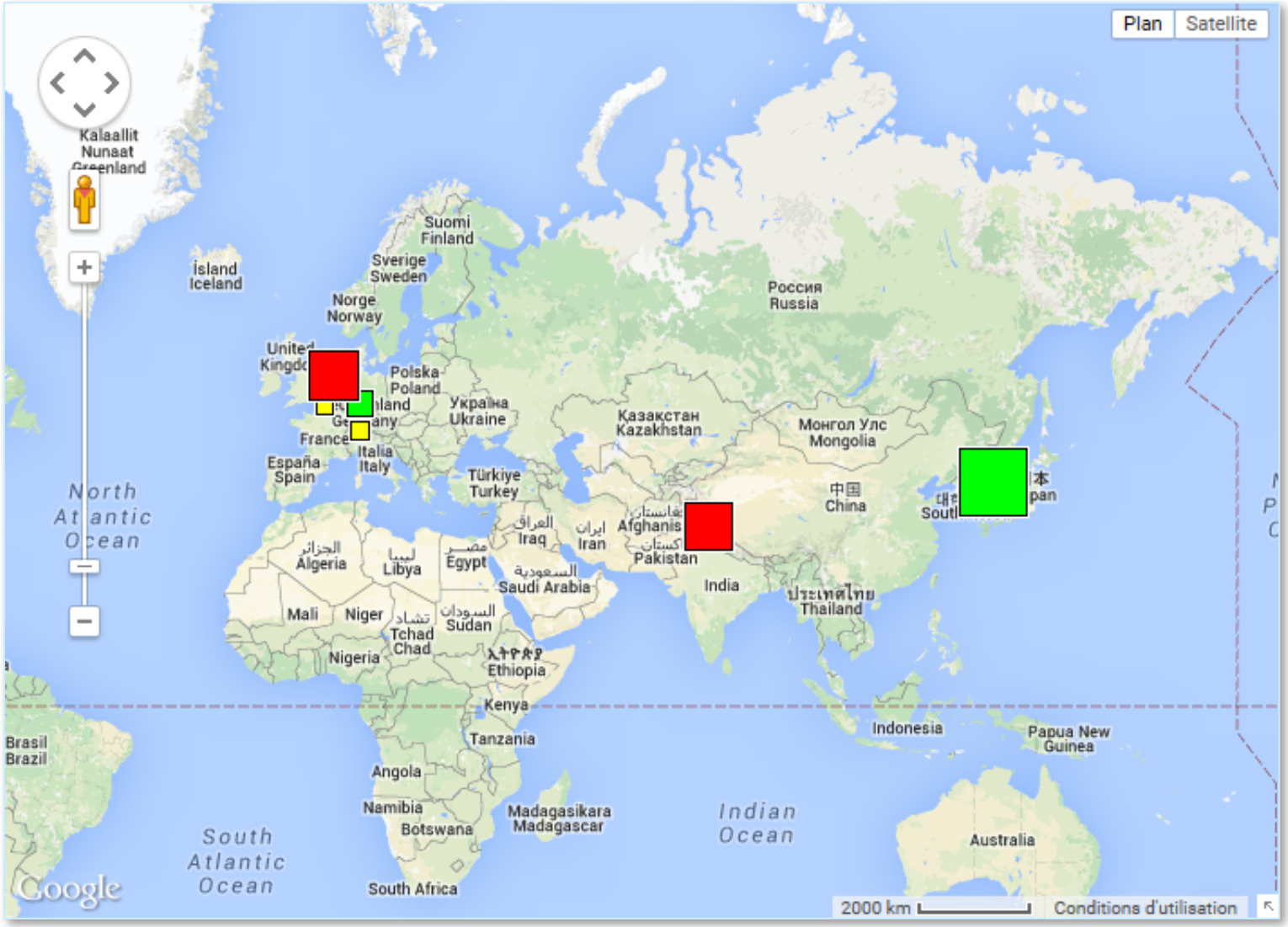




Other **PROMETHEE** Tools

- **PROMETHEE V**
  - Portfolio selection under constraints
- **PROMETHEE** Sort
- Bank Adviser
- **PROMETHEE** Efficiency Analysis
  - Input/output model
- …

Google Maps interface



Homework Assignment

- For Thursday.
- By small groups of 4 to 6 students.
- Set up a multicriteria decision problem:
  - Actual or fictive.
  - Including minimum 6 actions, 5 criteria and 2 scenarios.
  - Prepare the multicriteria evaluation table.
  - Think about preference functions and criteria weights.

Visual PROMETHEE

WWW.PROMETHEE-GAIA.NET

- **Visual PROMETHEE** software:
  - **Free Academic Edition**
  - **Business Edition**
- http://biblio.promethee-gaia.net :
  - Over 1570 references available.
- **Visual PROMETHEE** Manual (PDF or ebook)
- Services: Training, Coaching, Free seminars
- http://blog.promethee-gaia.net
- http://www.promethee-days.com Spring 2018
- LinkedIn group, Twitter, ResearchGate, …

Thursday 6

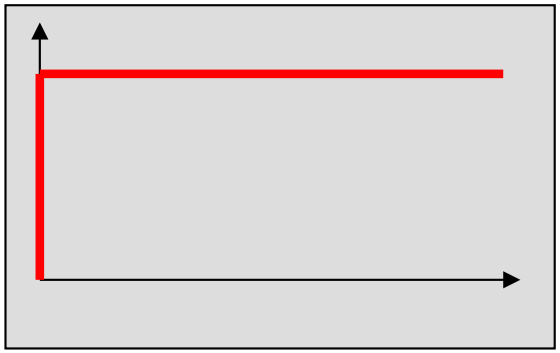
Practice

- Exercises.
- Case studies (homeworks).

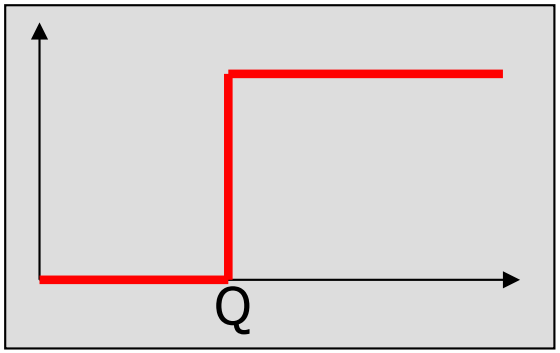
Steps for using **PROMETHEE**

1. Define the actions (list)
2. Define the criteria
   - Quantitative
   - Qualitative (scale)
3. Fill the evaluation table (evaluations).
4. For each criterion:
   - Choose the right type of preference function
   - Set the appropriate thresholds
5. Set the weights of the criteria

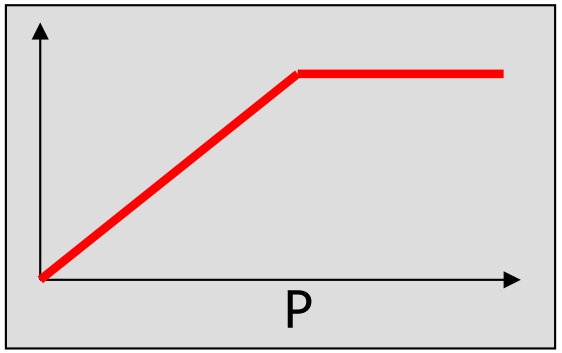
Preference Functions
(as in **Visual PROMETHEE** software)



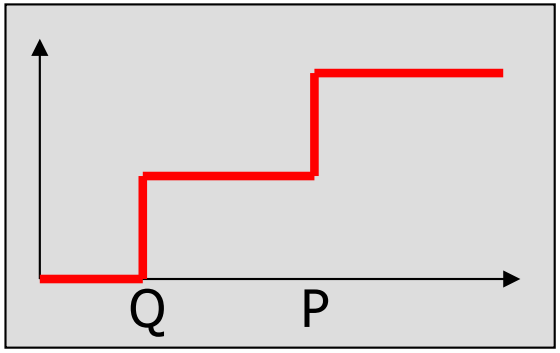
Usual



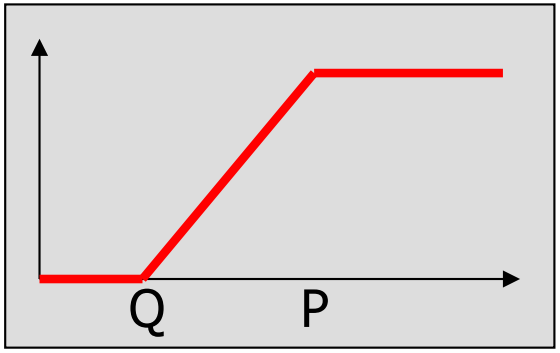
« U » shape



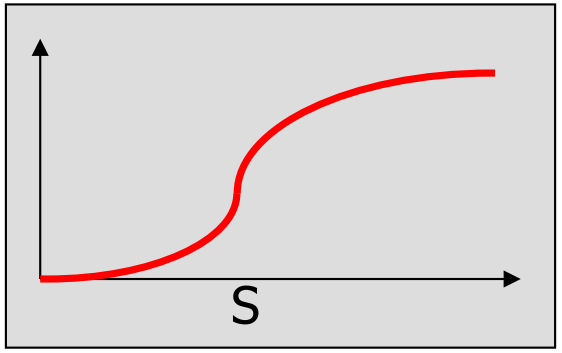
« V » shape



Level



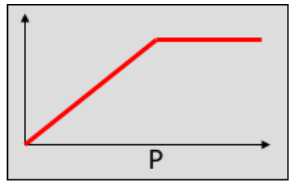
Linear



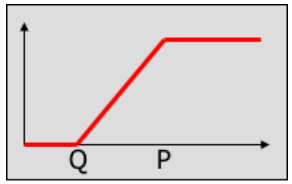
Gaussian

Preference Functions

- For continuous quantitative criteria (e.g. cost, price, power):
  - V-shape (no indifference threshold)
  - Linear

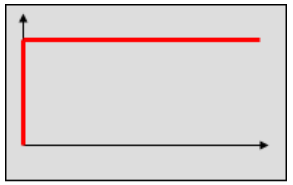


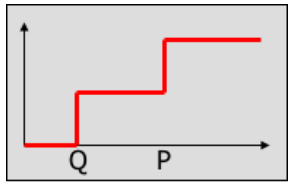
« V » shape



Linear

- For qualitative or discrete quantitative criteria (e.g. « very good to very bad », number of USB ports):
  - Usual (no thresholds)
  - Level


Usual



Level

Think about…

- Using action categories:
  - To identify similar actions by color.
- Using clusters and groups of criteria:
  - Two-level hierarchy:
    - Clusters are main families of criteria (economy, environment, social, …),
    - Groups are subsets of related criteria within a cluster (air, water, landscape, … within environment).
  - Color code.
  - Grouping for easier sensitivity analysis.

Next…

- First: Thanks to all of You!
- Continue…
- Check http://www.promethee-gaia.net
- Join **PROMETHEE** methods LinkedIn group
- Download **Visual PROMETHEE**
  - Free full-featured **Academic Edition**
- Interact with us:
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  - **PROMETHEE *Days* 2018** in Heraklion!

    http://www.prometheedays.com